This is a reproduction of a library book that was digitized by Google as part of an ongoing effort to preserve the information in books and make it universally accessible.

Google books

https://books.google.com

B 404893

Google

1837
ARTES VERITAS SCIENTIA
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
COLLEGE
OF
ENGINEERING

[redacted]

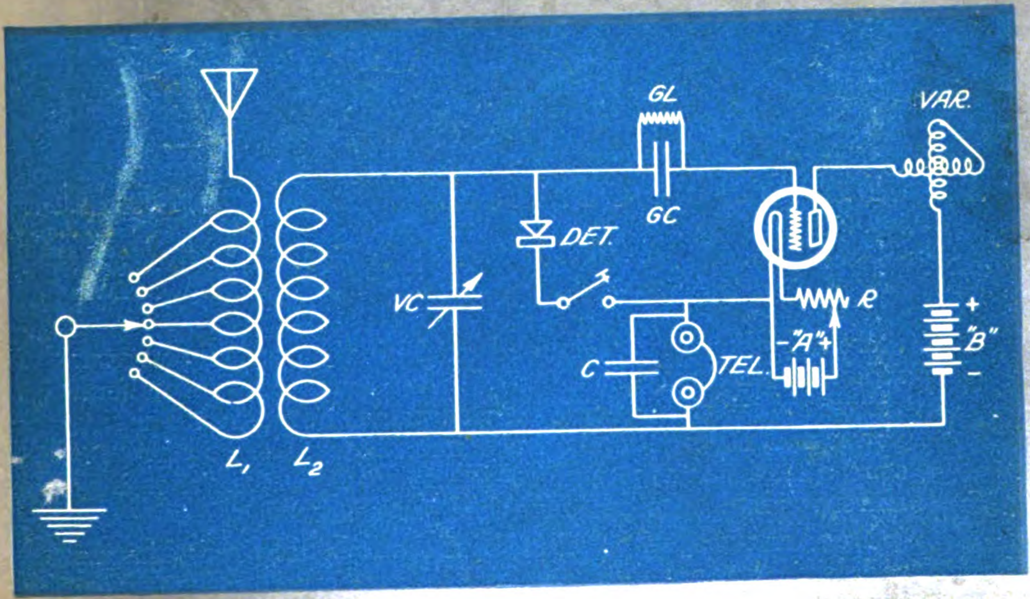
TK
6540
P83

Popular Radio

Edited by KENDALL BANNING

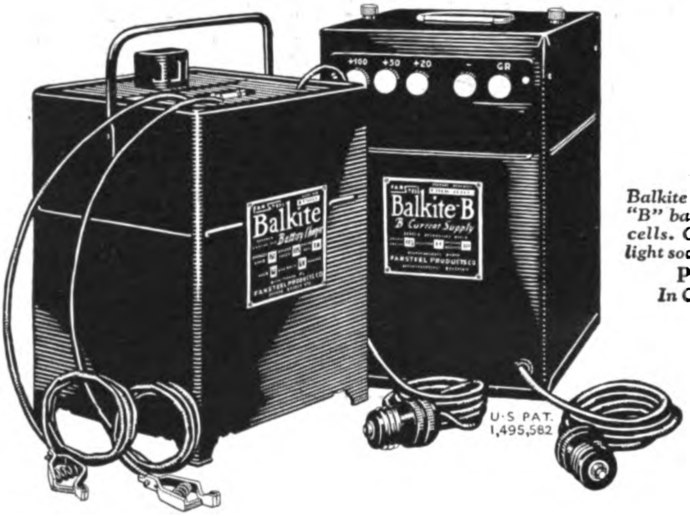
25¢

★ JULY 1925



Annual
HOOK-UP NUMBER

Containing 101 of the Best Radio Circuits, Revised and Brought Up-to-date



Balkite Battery Charger. *Charges 6 volt "A" storage batteries.*
Price $19.50
West of Rockies **$20**
In Canada **$27.50**

Balkite "B"—replaces "B" batteries and dry cells. Operates from light socket.
Price $55
In Canada **$75**

A uniform, constant power supply for both "A" and "B" circuits

Here at last is a convenient and unfailing power supply for your radio set. Balkite Radio Power Units furnish constant uniform voltage to both circuits, and will give your radio set greater clarity, power and range. The Balkite Battery Charger keeps your "A" storage battery charged. Balkite "B" replaces "B" batteries entirely and supplies plate current from the light socket.

Based on the same principle, both the Balkite Battery Charger and Balkite "B" are entirely noiseless. They have no bulbs or moving parts, and nothing to break, adjust or get out of order. They have a very low current consumption, are simple and efficient in operation, and can be put in use at any time by merely connecting to a light socket. Both are guaranteed to give satisfaction.

Sold by leading radio dealers everywhere

FANSTEEL
Balkite *Radio Power Units*

BALKITE BATTERY CHARGER— BALKITE "B" PLATE CURRENT SUPPLY

Manufactured by FANSTEEL PRODUCTS COMPANY, Inc., *North Chicago, Illinois*

The adjustable Table-Talker much improved—but still $10.00

Two big improvements—but no boost in price! Now the *Table-Talker* is adjustable. It has a convenient little lever that does a big job—increases the volume, snaps up the sensitivity. And a gooseneck horn that makes each sound clearer, fuller, more real!

Ten dollars is still the price. But uncountable are the hours of fun and interest and gaiety it will give.

50c additional
West of the Rockies

Brandes

Copyrighted by C. Brandes, Inc., 1925

POPULAR RADIO

EDITED *by* KENDALL BANNING

CONTENTS *for* JULY, 1925

(*Cover design by Frank B. Masters*)

VOLUME VIII NUMBER 1

A Forerunner of Tomorrow's Broadcasting........................FRONTISPIECE
A Probable Solution of the Broadcasting Problem—"Super-broadcasting"..............*Laurence M. Cockaday*..*Page* 3
Handy Tools for Radio Fans.. 13
No. 5: The File
Simple "How-to-Build" Articles for Beginners..*Albert G. Craig*............ 14
No. 10: How to Build a Two-stage Resistance-coupled Amplifier
The Best 101 Hook-ups........................*Technical Staff*............ 17
"What Set Shall I Buy?"....................*Technical Staff*............ 68
Second Installment
Broadcast Stations in the United States.......................... 72

DEPARTMENTS

Hints for Amateurs..........................*Albert G. Craig*............ 79
What Readers Ask............................*Laurence M. Cockaday*...... 80
In the World's Laboratories.................*E. E. Free*................ 82
The Broadcast Listener......................*Raymond Francis Yates*..... 88
What's New in Radio Apparatus...............*Technical Staff*............ 92
Broadcasts..................................*David Lay*................ 96

VOLUME VIII JULY, 1925 NUMBER 1

Published monthly by Popular Radio, Inc., 627 West 43rd St., New York, N. Y., telephone number, Chickering 1906; Douglas H. Cooke, President and Treasurer; Kendall Banning, Vice-President; Laurence M. Cockaday, Secretary; Joseph T. Cooney, Asst. Treasurer. Price 25 cents a copy; subscription $3.00 a year in the U. S., Canada and all countries within the domestic postal zone; elsewhere $3.50 a year, payable in advance. The International News Company, Ltd., No. 5 Bream's Bldg., London, E. C. 4, sole distributors in England. Entered as second class matter April 7, 1922, at the Post Office at New York, N. Y., under the act of March 3, 1879. Copyright, 1925, and title registered as a trade-mark by Popular Radio, Inc. Copyright in Great Britain by Popular Radio, Inc., 6 Henrietta St., Covent Garden, W. C., London, England.

Printed in U. S. A.

LAURENCE M. COCKADAY, *Technical Editor*
E. E. FREE, Ph. D., *Contributing Editor* JOHN V. L. HOGAN, *Contributing Editor*

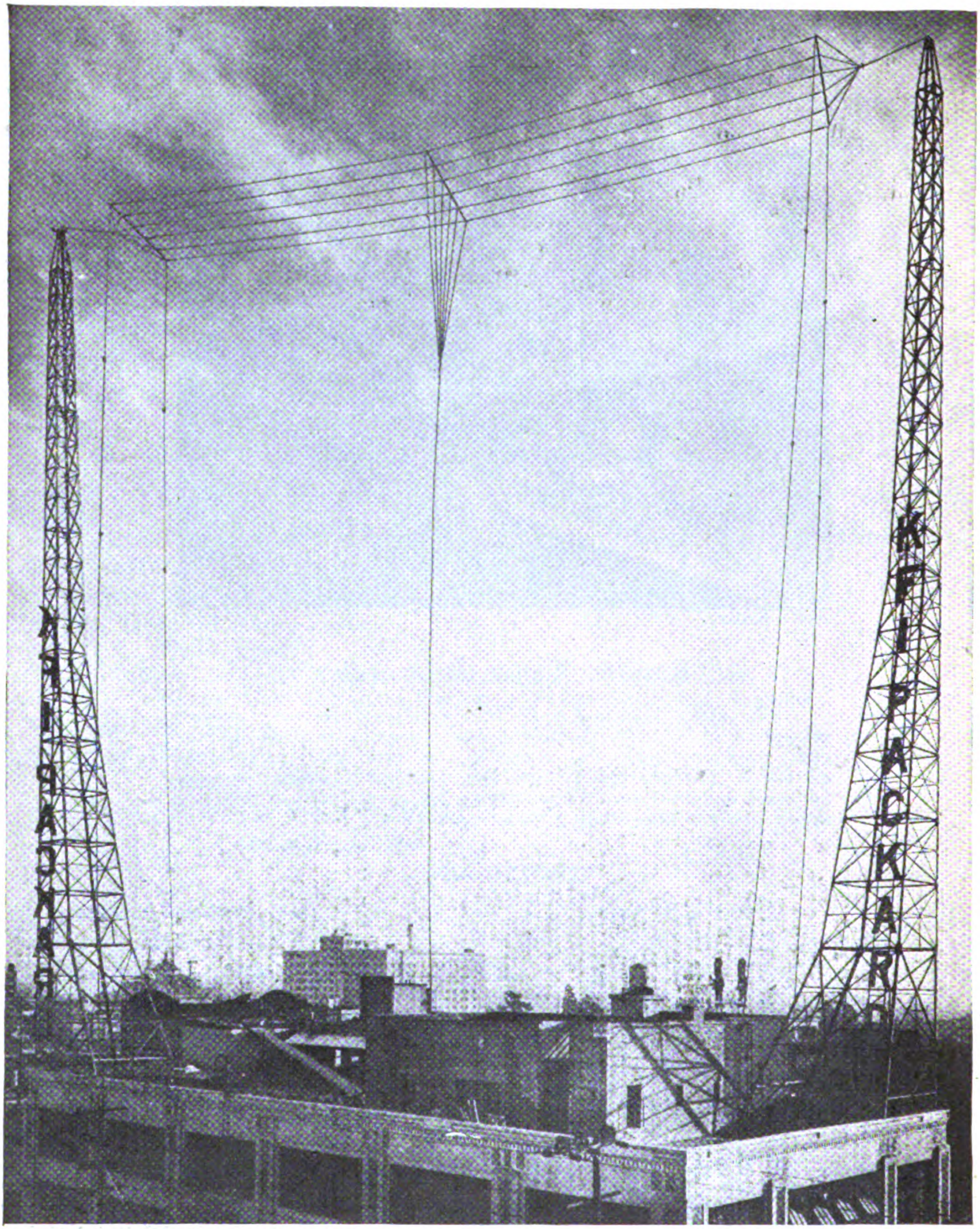
For advertising rates address
E. R. CROWE & COMPANY, INC.
New York: 25 Vanderbilt Avenue Chicago: 225 North Michigan Avenue

Kadel & Herbert

"Radio's Finest Interpreter"

A MAGAZINE *dedicated to the presentation of an art or science in terms and language that the public can understand and appreciate, is in very truth the House of the Interpreter. The radio art has no finer interpreter than* POPULAR RADIO, *which combines an exact and thorough knowledge of this great science with the happy gift for interesting popular expression.*

—R. A. WEAGANT



Courtesy of Earle C. Anthony

A Forerunner of Tomorrow's Broadcasting

It is from such great antenna systems as this one (the powerful station KFI in Los Angeles), that programs of national importance may be broadcast throughout the entire country. And it is this type of power station that is destined to become a part of the plan for attaining "super-broadcasting" and to be an important factor in solving the broadcasting problem.

Engin.
Walr.

Popular Radio

VOLUME VIII JULY, 1925 NUMBER 1

A PROBABLE SOLUTION OF THE BROADCASTING PROBLEM—

"SUPER-BROADCASTING"

Questions That the Radio Interests Must Eventually Answer—

WHAT *constitutes program features of superlative merit?*
FROM *what stations shall these "super features" be broadcast?*
HOW *can these programs reach the maximum number of listeners?*
WHO *will pay the costs of maintenance of the stations?*
HOW *will the broadcast artists receive remuneration?*
WHO *will pay authors' and composers' royalties on copyright features?*

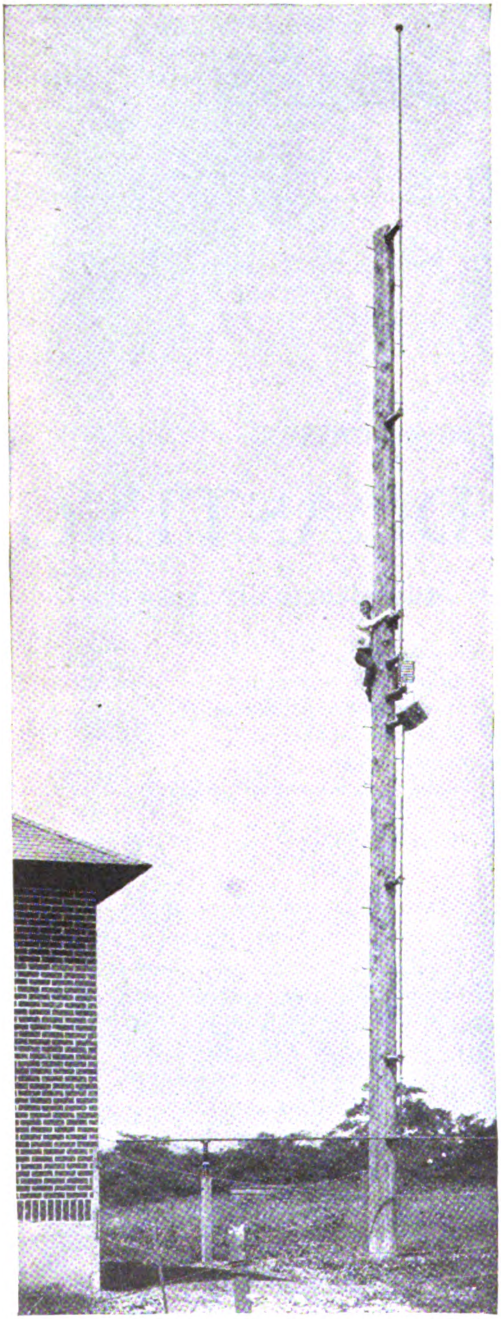
By LAURENCE M. COCKADAY

BROADCASTING has grown in the past three years from the experimental work of a few scientifically-minded amateurs to the greatest medium of disseminating news, entertainment and education that the world has ever known.

Today there are 475 class A broadcasting stations in this country and 90 class B stations. The former broadcast on wavelengths ranging between 280 and 545 meters, and are required to have a minimum of 500 watts of power in the antenna. The latter operate on wavelengths between 200 and 280 meters, and are limited to a maximum of 500 watts in the antenna. These two classes of stations total 565. Between them they cover the entire country.

The quality of the broadcast programs that are sent out from these stations varies to a marked degree. In those areas that are served by stations which are noted for the general excellence of their programs, the interest in radio has been developed to the benefit of the radio fan and to the profit of the radio dealer and manufacturer. As a consequence, the growth of radio has been in reality the direct reaction of the development of individual broadcasting stations. Those stations have been most successful that have given the best programs to the largest number of listeners.

In other words, the public interest in radio and the radio industry itself is dependent upon the maintenance of a higher standard of broadcast program, and the future of radio will be deter-



Westinghouse

A RADIO "RELAY STATION"

This is the type of short-wave antenna that is used at station KDKA for relaying radio programs to other stations. It is a vertical rod mounted rigidly on evenly spaced insulators. This prevents swinging and changes in the transmitted wave on a pole.

mined by the character of programs that will be furnished.

On the maintenance of broadcast programs the whole structure of the radio interests rests.

How shall this be accomplished?

In the answer to this question lies the problem of super-program building—the selection of those features of the broadest possible interest, of the best possible quality and of the greatest national import.

And here is where "superbroadcasting" enters the situation as a probable solution.

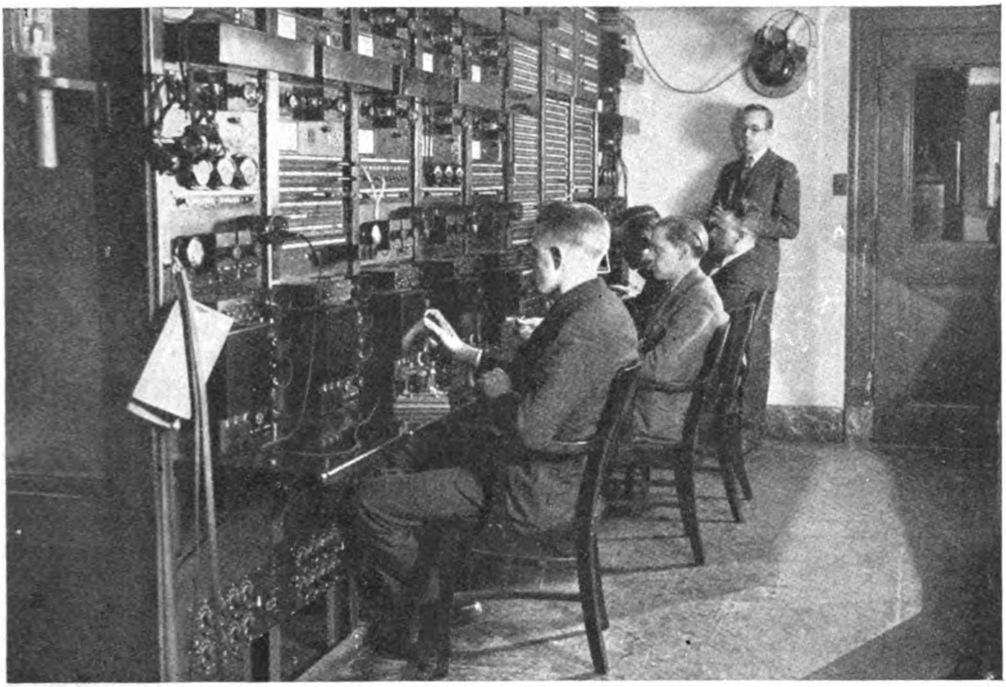
"Superbroadcasting" is the term that may be applied to what is, in effect, universal broadcasting; *i. e.,* the broadcasting of those program features of outstanding excellence that may be received over the entire country or over the entire continent or, conceivably, over the entire world at the same moment. This may be attained in three ways, any one of which may be used separately or in combination.

These three ways may be summarized thus:

1. A small number of strategically located broadcasting stations that operate on "super-power" ranging from 5,000 to 20,000 watts;
2. The linking together of broadcasting stations by wire, so that the same program may be sent out from them simultaneously;
3. The linking together of broadcasting stations by means of "relay stations," which pick up programs broadcast from other stations simultaneously on a short wavelength (say 90 meters), and re-broadcast them on a regular wavelength.

Let us consider for a moment the first of these methods—the super-power stations.

It has been estimated that fifteen or twenty super-power stations of 5,000 watts or more could cover the whole of



Kadel & Herbert

HOW BROADCAST STATIONS ARE LINKED TOGETHER BY WIRE

Here is a long-distance control board for the telephone lines that are used to connect a number of widely separated broadcasting stations, so that they may all transmit the same broadcast program.

the United States with as many different programs (see Figure 1). This could be done in such a way that a listener in any part of the country, with a receiver of only medium sensitivity, could pick up that particular type of program or feature in which he was interested, and he could receive it with good volume and in pleasing quality.

This system of broadcasting would undoubtedly help to popularize a simple receiver (of not more than three or four tubes) which would be easy to tune (probably a single-control unit) and that would be a profitable instrument to sell at a price well within the reach of everybody's pocket. In fact, a receiver capable of receiving signals from a super-power station at a distance of 2,000 or 3,000 miles can be manufactured at a considerably lower cost to the ultimate consumer than the ordinary receivers sold today. At the same time, the manufacturers could incorporate in these simplified receivers an audio-frequency amplifier of much better quality than is used today, so that the reproduction of the program in the homes would be much more enjoyable than in even the most expensive of the receivers now in use.

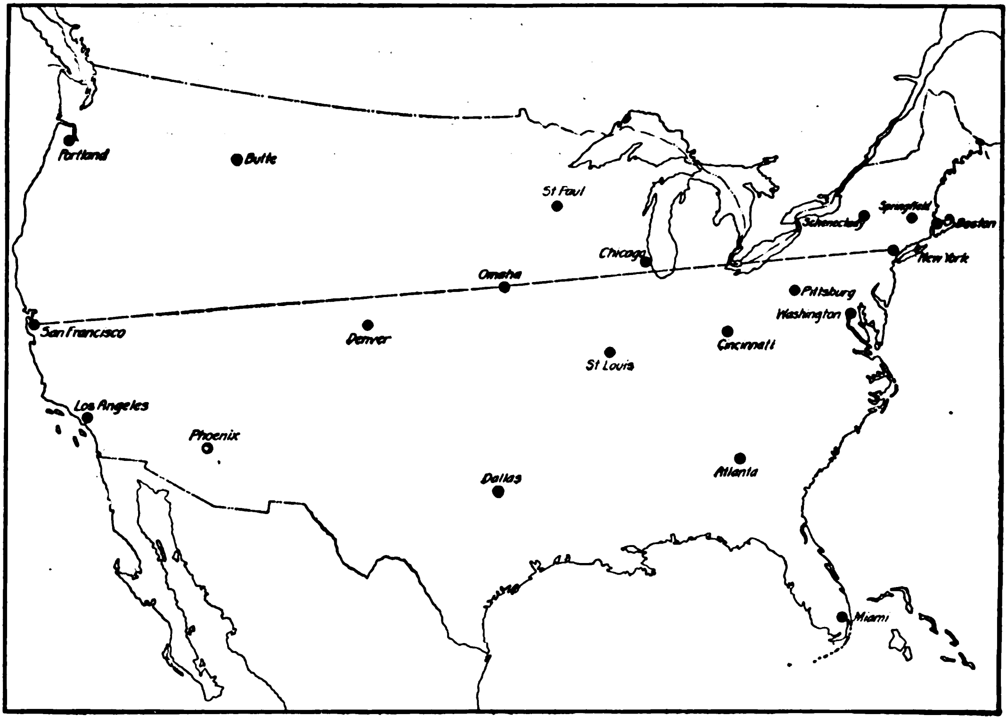
A super-power station, however, if it is located in the midst of a large city, causes an undue amount of interference. This is especially true if the receivers now in general use are employed. To avoid this interference it may become necessary to install and operate super-power stations outside of the crowded areas. No super-power station (in the writer's opinion) should be located in the center of a city or town. It should be built at a distance of fifteen or twenty miles from a congested district. It should be located at some place where there are few residents—as, for example, in low, flat marshes or up in the mountains on some high peak.

The studios for these stations would not, of course, be at such a distance from town, as it would be difficult to induce performers or lecturers to travel to them. The studio itself would be located in the most accessible district of the city or town, and would be connected to the transmitting station by telephone lines. In this way, the multitudes in the city would not have a broadcasting station of tremendous power "in their back yards," so to speak, and they would be able to tune it out with a receiver of only fair selectivity. But other broadcast listeners at great distances would be able to pick up these programs from this station although the nearer super-power stations might be transmitting at the same time.

There are a number of super-power stations now in operation in the United States, including stations KDKA at East Pittsburgh, Pa.; WBZ at Springfield, Mass.; WOC at Davenport, Ia.; KFI at Los Angeles, Cal.; WLW at Cincinnati, O.; WEAF at New York City; KGO at Oakland, Cal.; WGY at Schenectady, N. Y., and WSB at Atlanta, Ga. These stations have an average power of 5,000 watts with minimum and maximum powers ranging from 2,500 watts to 50,000 watts in one or two cases.

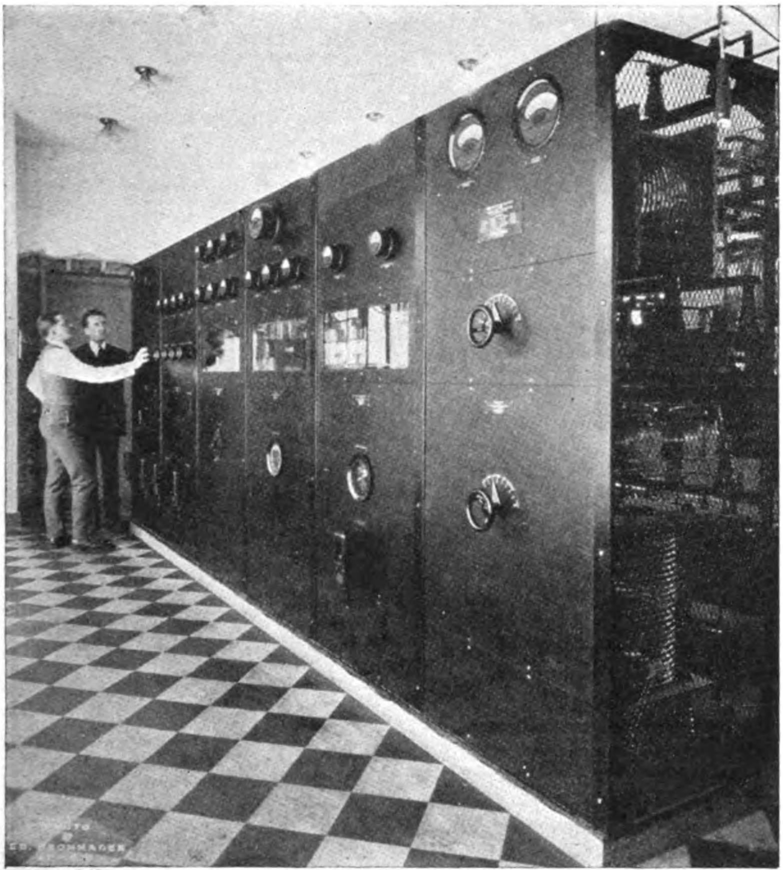
By the second method of super-broadcasting, a number of local stations of low, medium or high power would all be connected to each other by means of special land wires—and all connected to a single broadcasting studio.

These separate stations, properly distributed around the whole country (see



HOW SUPER-POWER STATIONS SHOULD BE DISTRIBUTED

FIGURE 1: *A number of high-powered radio stations may supply the country with the same number of national programs, if the wavelengths of the stations are far enough apart to avoid interference. A station at Omaha would need but half the power required if it were located at New York or San Francisco.*



Ed. Frommader

A FAMOUS SUPER-POWER TRANSMITTER

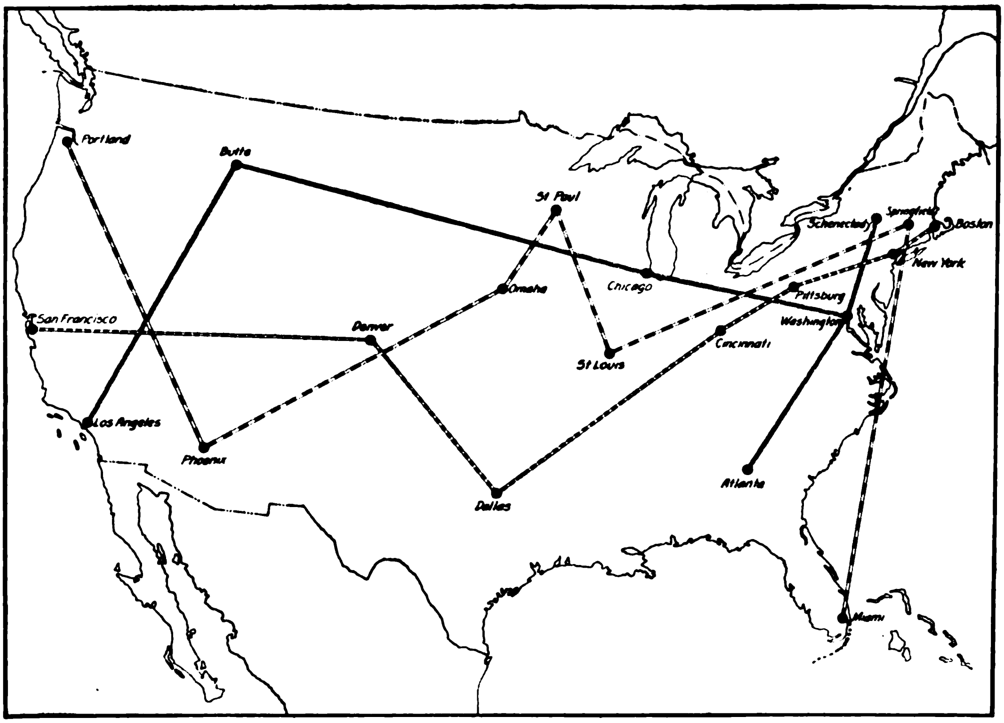
This is the recently erected panel transmitter of station WOC, at Davenport, Ia. It is one of the greatest super-power stations in the world and is heard throughout the year from coast to coast on a loudspeaker with simple three or four-tube receivers.

Figure 2) and each broadcasting the same program, could be received throughout the entire nation with the same type of simplified receiver as would be required to tune in the super-power stations. In other words, this second method of broadcasting would make it possible for any person in any part of the country to pick up a program originating at a distant point with a receiver that would not strain even the most modest pocketbook.

This method, however, has a disadvantage, in that it would make available at one particular time only a single program. This objection, however, could be overcome by using a series of interconnected low-power stations, with (say) one program from the east on one chain, another program from the western part of the country on another chain of stations, and so on.

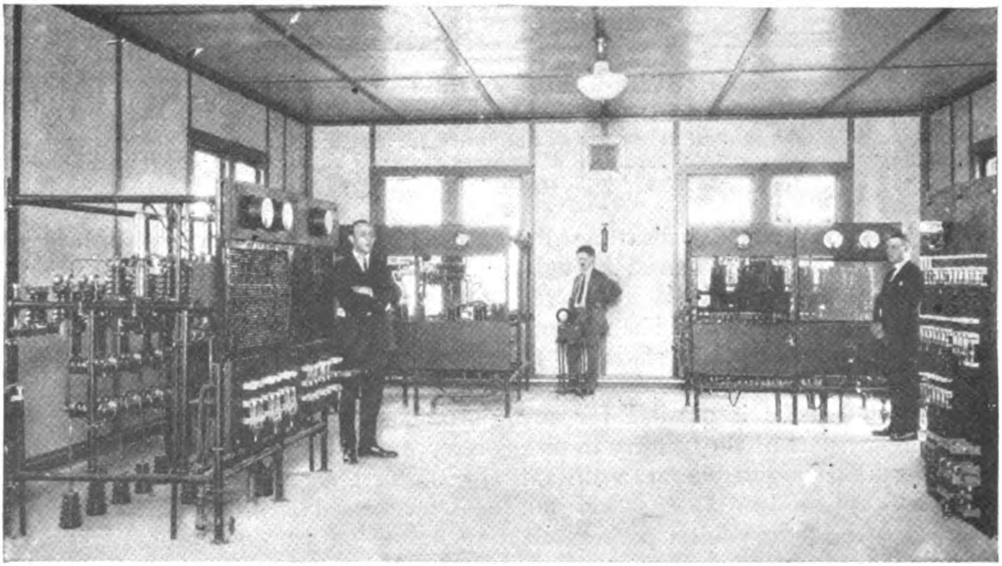
But this method has one outstanding advantage; it would reduce local interference considerably over that obtained by the first method.

Of course, this second method is only applicable on one continent. It cannot be used for linking stations over large bodies of water, as it is necessary to run a high quality telephone line between every one of the stations to be connected in the chain.



THE TELEPHONE LINK FOR BROADCASTING STATIONS

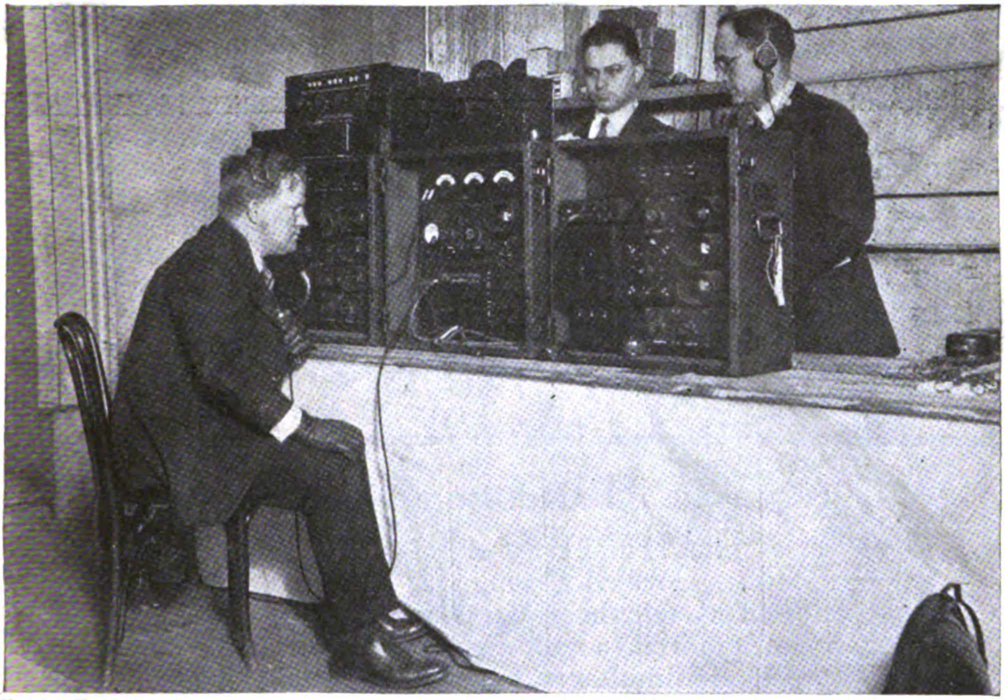
FIGURE 2: *Seven stations with a 1,000-mile range and located at proper points throughout the country would be able, if connected by telephone wires, to broadcast a program simultaneously to the whole country.*



Westinghouse

A PIONEER IN SHORT-WAVE TRANSMISSION

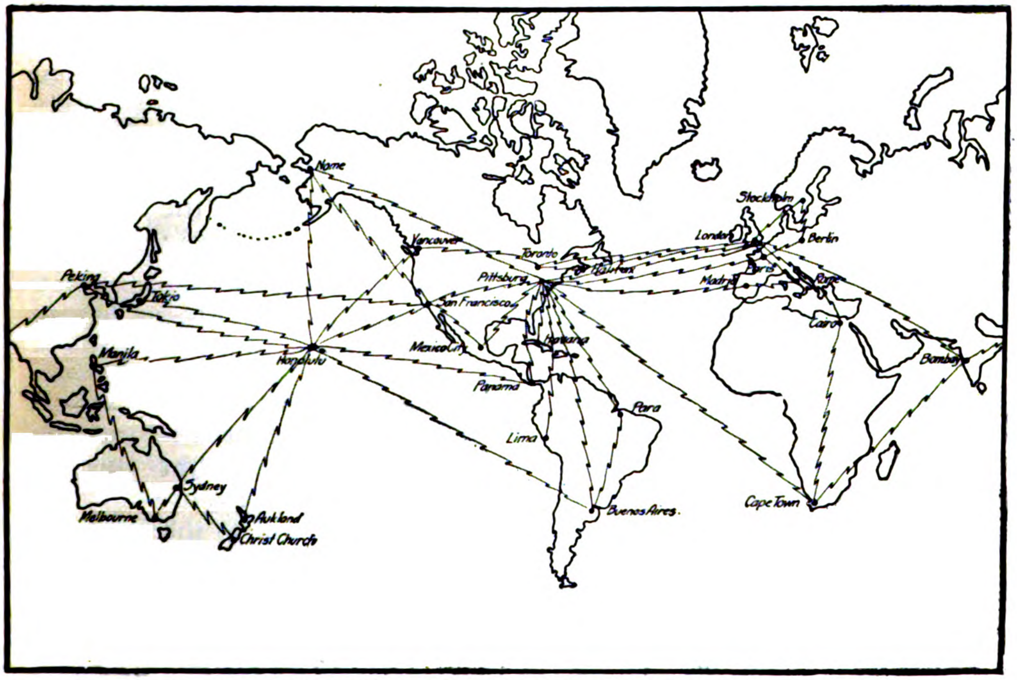
Here is the apparatus used at the new experimental radio station at KDKA of the Westinghouse company. By means of this high-powered short-wave system, radio programs have been transmitted across the continent and even across the ocean.



Kadel & Herbert

THE START OF A NATIONAL RADIO EVENT

The pick-up apparatus used at the Capitol when the inaugural ceremonies were broadcast so that the entire country could listen in.



THE INVISIBLE RADIO NET AROUND THE GLOBE

Figure 3: *The diagram shows how short-wave radio stations could be tied together.*

The third method of super-broadcasting provides for the use of a short wave radio link between a number of well distributed transmitting stations of low, medium or high power, so that they all could re-broadcast on a higher wavelength the programs transmitted to them by the "mother" station on a short wave. Programs broadcast from these separate radio-linked stations, properly distributed throughout the whole country, or in fact, throughout the whole world (see Figure 3), each broadcasting the same program, could be received anywhere within the range of any one of the separate stations—and with the same type of simplified receiver already mentioned in connection with the other two methods of super-broadcasting. This latter method, however, has the added advantage that its service is available to any transmitting station at any place within the range of the short wave mother transmitter. It does not rely on expensive land lines for its operation and its apparatus and maintenance would not include these or their

Tomorrow's Broadcasting May See—

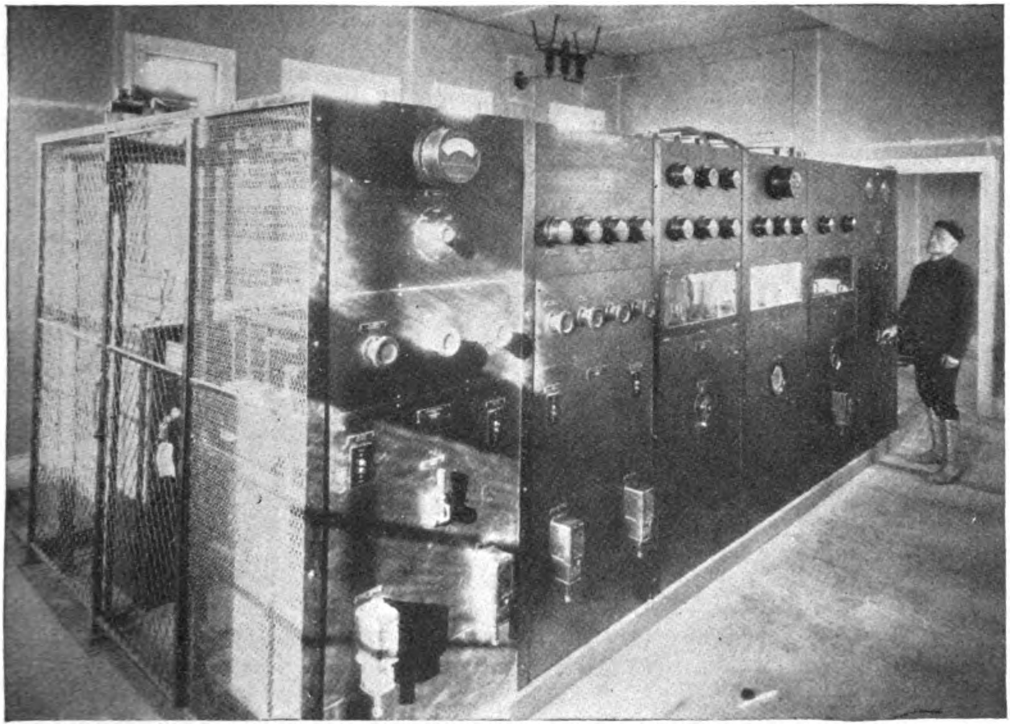
1: A small number of super-power broadcasting stations, located throughout the country and connected by telephone wires so that programs of national importance and of superlative quality may be broadcast simultaneously for the benefit of all;

2: These broadcasting stations authorized to collect toll charges for the rental of these stations for educational, publicity or other purposes, so that funds may be thus secured for their maintenance;

3: Manufacturers of radio sets, and manufacturers of parts that are required for radio sets, assessed on some fair and equitable basis so that those who profit from the sales of radio equipment may contribute toward the maintenance of the stations; (on this point there is much controversy);

4: These broadcasting stations operating under the direction of a representative group of public-spirited citizens of practical experience, acting under the supervision of the Secretary of Commerce;

5: The entire revenue derived by these broadcasting stations—which might conceivably amount to several million dollars a year—devoted exclusively to the maintenance of the stations and to the payment of the broadcasting artists and to the payment of proper royalties to the composers and authors whose work is thus published for the entertainment or for the instruction of all our people.



Crosley Radio Corp.

A 5,000-WATT STATION

This is the high-powered transmitter which is now working day and night at station WLW in Cincinnati. This station may be heard at any time in the evening throughout the United States and in many foreign countries.

accompanying repair work. It would rely wholly upon short wave ether vibrations for the inter-connecting link between the local broadcaster and the mother station transmitting the original program. On the other hand, it might prove to be difficult to transmit to the whole world by this method on account of static conditions in any one vicinity. This condition, however, is ameliorated by the fact that static disturbances are very slight or almost totally absent on certain short wavelengths. It would probably assure the greatest range for super-broadcasting.

Any one of these three methods of broadcasting points a way to a practical solution of the national broadcasting problem. No one of these three systems would interfere in the least with the operation of our regular broadcasting as it is carried on today. There would be ample field for medium-powered local stations, of, say, 250 watts for the transmission of purely local news and items of local interest. These stations should be equipped with the best modulating apparatus obtainable, so that their programs will be reproduced in the receiving sets with as good quality as from the super-broadcasting stations. These local stations would fit in with either of the latter two plans, so that they too could broadcast national programs, when they are of sufficient importance to assure interest on the part of the local listeners.

It is quite possible that certain elements of all three of these schemes may be incorporated in the ultimate plan for world broadcasting. Such a plan might include the following:

(1) A number of super-power stations well distributed throughout every country in the world, and arranged so

that no two adjacent super-power stations would be transmitting on approximate wavelengths;

(2) A number of local medium-powered stations in every large city (not more than four to a large city and, possibly, only one in small towns) all equipped so that they could be tied in with some national program by means of telephone wires;

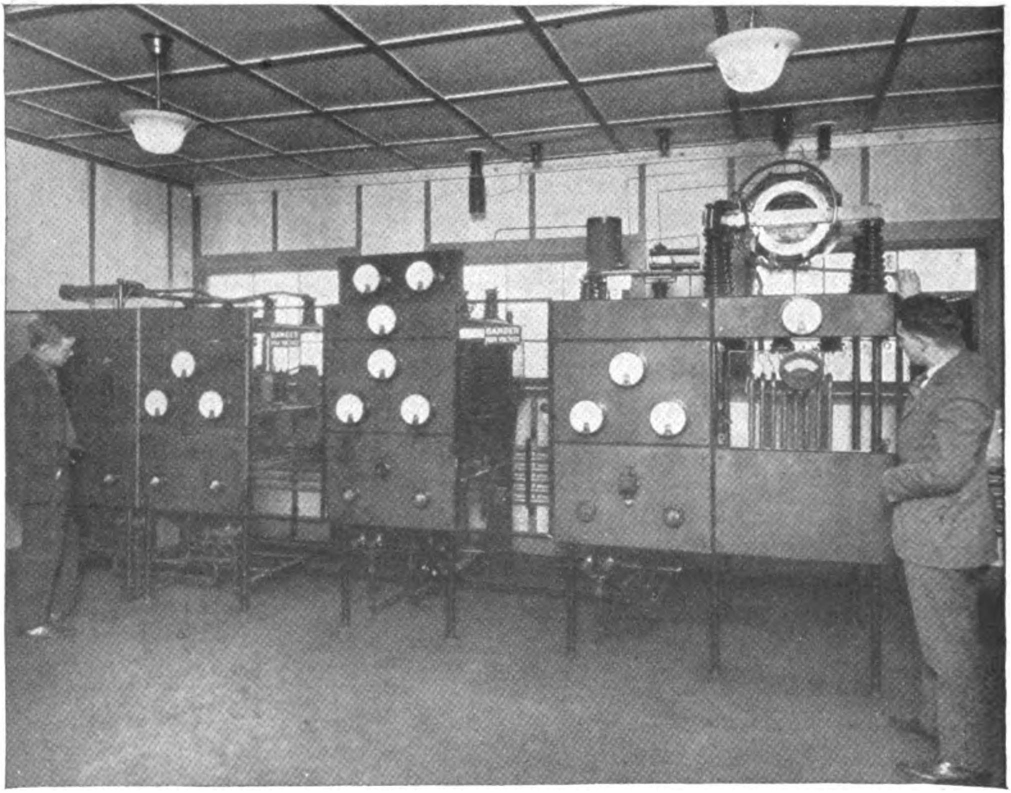
(3) A small number of high-powered short-wave broadcasting stations (two or three to each nation) that might be used as relay stations across large bodies of water (such as the Atlantic and Pacific Oceans), to be used as an interconnecting link between the various national broadcasting chains;

(4) A comprehensive telephone landwire link for every nation, which would be used for no other purpose than to supply national broadcasting programs to any client broadcasting station that would pay for the service.

When some such plan as this is put into effect and all of the broadcasting facilities of the nation, or of the whole world, are pooled, so to speak, the success of radio broadcasting will be reasonably assured.

And such a comprehensive broadcasting plan would tend not only to reduce the price of receiving apparatus but also to increase the quality of reception throughout any area at the same time cutting down the trouble from interference.

When these steps have been taken radio broadcasting will be available to practically every family in the world.



Westinghouse

ANOTHER "SUPER" STATION

The transmitting apparatus at station WBZ in Springfield, Mass. Almost all radio listeners in the United States have at some time received programs from this powerful transmitter.

Handy Tools for Radio Fans: No. 5

From a photograph made for POPULAR RADIO

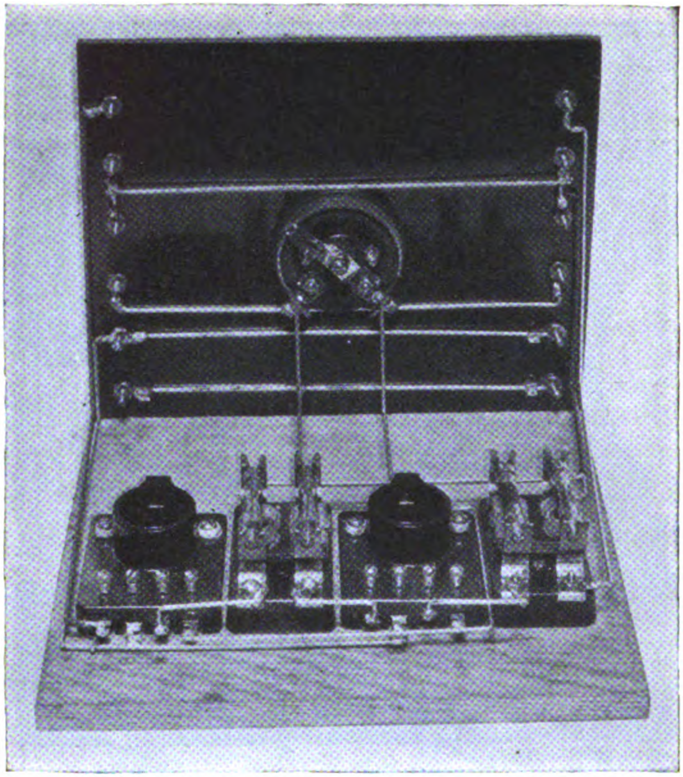
THE FILE

A tool of many uses

THE kit of tools for the set owner should include a file or a number of files of various coarseness and fineness. Files are indispensable for brightening up the contacts of vacuum tubes, for cleaning metal connections before soldering them and for trimming any metal brackets, or other hard materials that enter into set construction.

Many times the trouble in a receiver is due to corroded terminals of the tubes. This condition results in noisiness, loss of signal strength, or in some cases, no signals at all. A fine file applied to the prongs of the tube lightly, will assure good clean contact.

The preceding suggestions in this series were SIDE-CUTTING PLIERS, SCREW-DRIVERS, THE HYDROMETER *and* THE BATTERY-TESTING VOLTMETER.



THE REAR VIEW OF THE AMPLIFIER

Study this view in connection with the picture diagram of the hook-up on page 15. The location and connecting points of each wire appear clearly and you can determine just how to bend the wires to get the shortest connection with the proper clearance.

Simple "How-to-Build" Articles for Beginners

No. 10

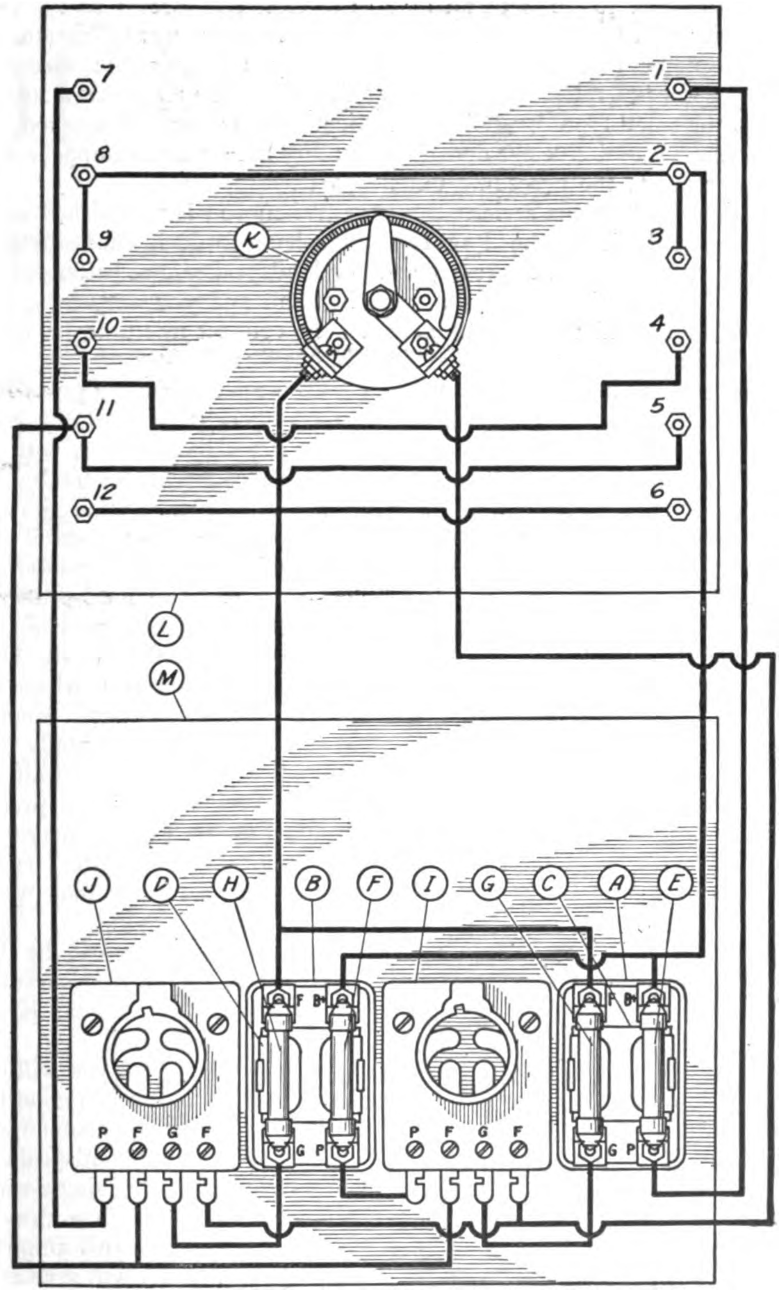
How to build a two-stage resistance-coupled amplifier for use with dry-cell tubes

By ALBERT C. CRAIG

COST OF PARTS: *Not more than* $11.00

HERE ARE THE ITEMS YOU WILL NEED—

A and B—Daven resisto-couplers;
C and D—Dubilier mica fixed condenser, .006 mfd.;
E, F and H—Durham metallized grid-leaks, ¼-megohm;
G—Durham metallized grid-leak, ½-megohm;
I and J—Remler sockets, Type 399;
K—"E-Z" Stat;
L—composition panel, 7 inches by 8 inches;
M—hardwood sub-base, 6½ inches by 8 inches; twelve binding posts.



THE "PICTURE DIAGRAM" OF THE HOOK-UP

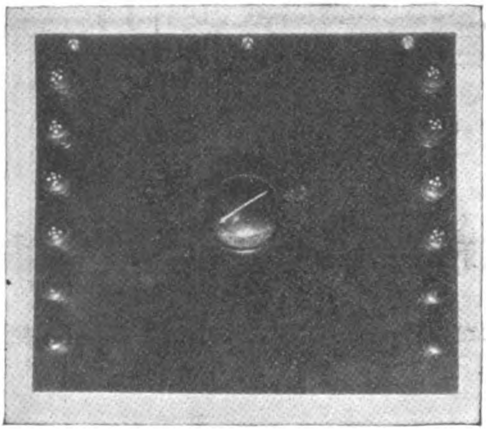
FIGURE 1: *This illustration shows the exact manner in which the instruments are placed on the panel and baseboard and how the wires run in relation to them. The upper rectangle shows the back of the panel, and the lower one shows the baseboard. All the parts are lettered to correspond with the designations in the text and in the list of parts.*

THIS tenth unit to be described in this series is a vacuum-tube audio-frequency amplifier that comprises two stages of resistance-coupled amplification for use with the small type dry-cell tubes. This unit will be found efficient and useful for connecting to the preceding units and tuners described in this series.

This unit was built in the POPULAR RADIO LABORATORY for the express purpose of submitting to the beginner a resistance-coupled amplifier that will give him the best reception possible, and at the same time teach him something about the problems involved in resistance-coupled circuits.

After you have decided to make this simple amplifier, take these pages to a radio dealer and ask him to supply you with the parts listed at the head of the article. When you have your parts ready for mounting, you may spread them out on a kitchen worktable and begin the construction of the set. Mount them on the panel and baseboard as shown in the picture diagram and the two photographs that accompany this article. These three illustrations show you exactly how to mount the instruments and also how to wire up.

Next, connect up the instruments in the electrical circuit as indicated specifically in the picture diagram.



THE PANEL ARRANGEMENT

This photograph shows the front view of the panel with the rheostat mounting in the center and the binding posts in two rows, one at each end.

If you follow the directions shown there you cannot make a mistake, as the instruments are all marked with designating letters that re-appear in the list of parts.

When you have finished wiring up, all you have to do is connect the telephones or loudspeaker, the batteries and the tuning unit and you are ready to "go."

To connect this unit, be sure to do the following:

Connect the binding posts 10 and 11 to your dry-cell "A" battery consisting of three dry-cells in series, with the positive terminal connected to binding post 11:

Then, connect the 67½-volt "B" battery to the binding posts 9 and 10 with the positive terminal connected to binding post 9. The loudspeaker should be connected to binding posts 7 and 8. Binding posts 1 and 2 go to the binding posts on the preceding unit, where you usually connect the telephones. Binding posts 3 and 4 may be used to apply the "B" battery directly from this unit to the "B" battery terminals of the preceding unit. Binding posts 5 and 6 may also be used to supply the "A" battery current to the two binding posts for that purpose on the preceding unit:

Place two tubes of the UV-199 or C-299 type in the two sockets, I and J, and turn on the rheostat K and the set is ready to work.

You will find that you will obtain wonderful reproduction if a good loudspeaker is used with this type of amplifier. For best results with a loudspeaker, it is recommended that the single-stage dry-cell amplifier described in a previous article be used in between this amplifier and the tuning unit. This will give exceptionally loud and clear results.

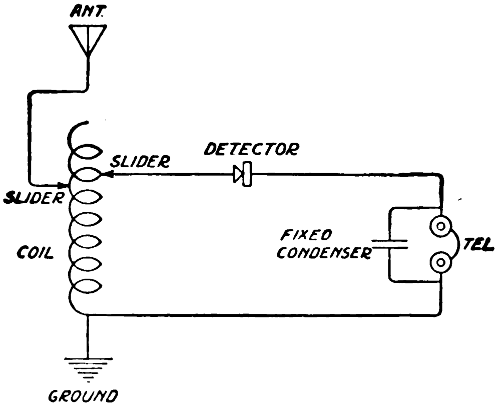
Do not turn the rheostat which controls the filament current to the two tubes any higher than is necessary to produce sufficient volume. This will conserve the batteries and lengthen the useful life of the tubes.

THE BEST

101 HOOK-UPS

HERE are listed—for the guidance of broadcast listeners and radio experimenters, and as a ready reference record—what Popular Radio believes to be the most efficient of the radio circuits that have been developed to date. Accompanying each diagram is information concerning costs of parts, selectivity, operation, construction and other practical features that will guide the builder or purchaser of a set that will meet his own particular needs. The approximate ranges as here given, are *yearly averages on actual records.* During the summer the actual ranges may fall to 50 percent of the value given, while in the winter, under the best of conditions, the actual ranges have been known to exceed the values given by as much as 500 percent.

Crystal Circuits



THE CONDUCTIVELY-COUPLED CRYSTAL CIRCUIT

Cost of parts: Not more than $10.00.

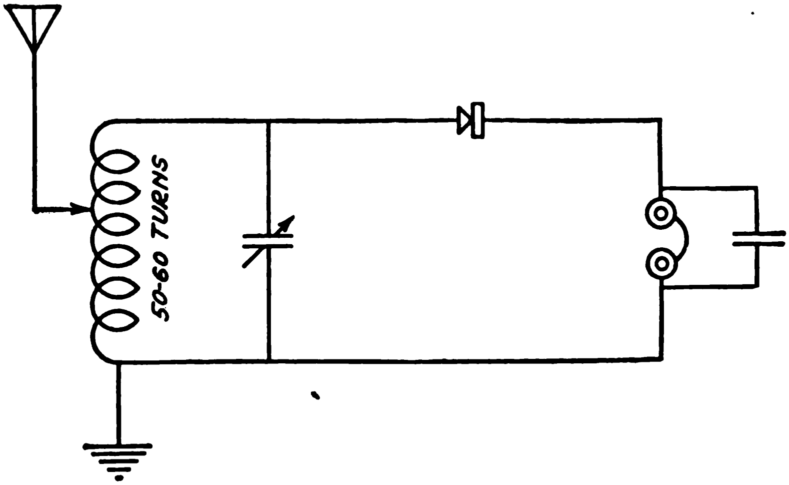
Selectivity: Fairly good.

Operation: Very simple. Only two controls are used; a primary and a secondary slider.

Ease of construction: No technical knowledge necessary.

Approximate range: 15 miles.

Outstanding features: This circuit is especially suitable for the beginner who wants to start out by building the simplest set that will give him clear reception of local signals at the smallest cost.



THE CAPACITY-TUNED CRYSTAL CIRCUIT

Cost of parts: Not more than $12.00.

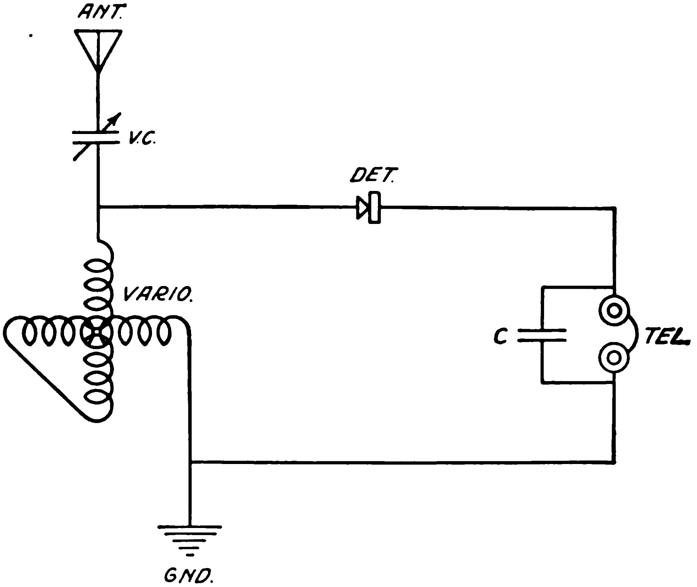
Selectivity: Good.

Operation: Simple. Only two controls; a primary slider and a secondary variable condenser.

Ease of construction. Nothing complicated.

Approximate range: 15 miles.

Outstanding features: The circuit is more selective than the ordinary conductively-coupled tuner and the variable condenser gives smoother wavelength control.



SINGLE-CIRCUIT CRYSTAL SET

Cost of parts: Not more than $18.00.

Selectivity: Fair.

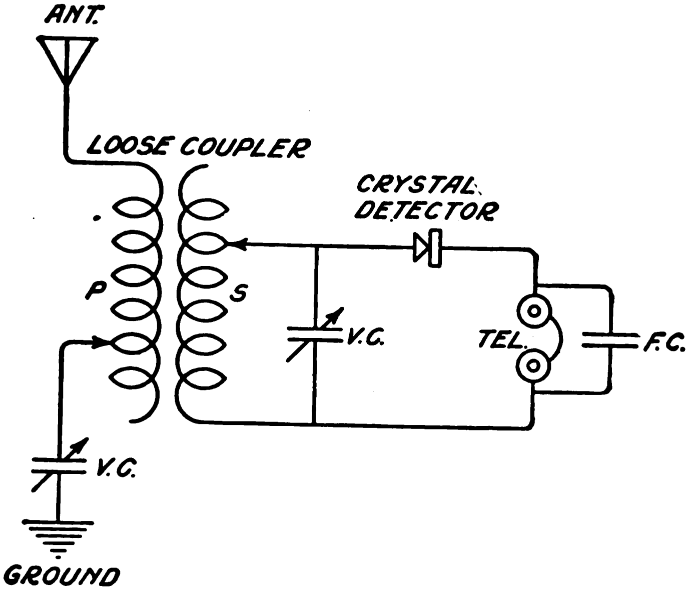
Operation: Simple. The antenna circuit is tuned by both the condenser and the variometer. The closed circuit is controlled by the variometer.

Construction: Very simple to make.*

Approximate range: 15 miles.

Outstanding feature: A good, inexpensive set for the city dweller who is content to listen to local programs with the headphones.

*(*See* Popular Radio, *December, 1922, page 292, for details of operation.*)



INDUCTIVELY-COUPLED CRYSTAL RECEIVER

Cost of parts: Not more than $22.00.

Selectivity: Good.

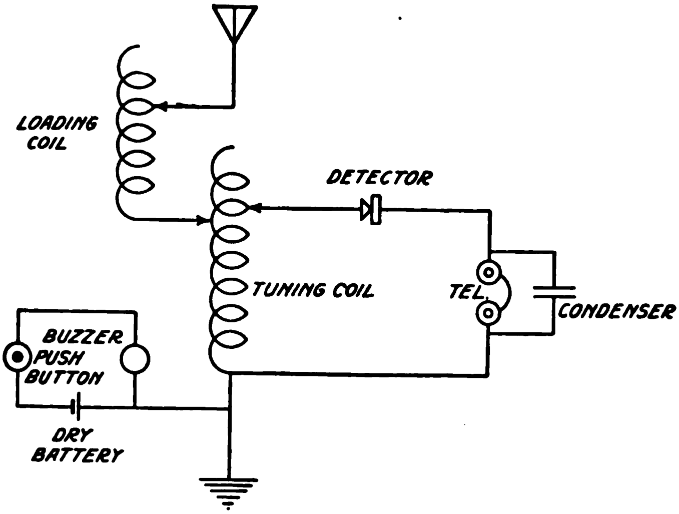
Operation: Fairly simple.

Construction: The whole set can be constructed on a board and wired up in an hour or two.*

Approximate range: 15 miles.

Outstanding feature: The sharpest tuning crystal receiver that it is possible to make.

*(See Popular Radio, *August, 1922, page 293, for constructional details.*)



CONDUCTIVELY-COUPLED CRYSTAL SET WITH LOADING COIL AND BUZZER TEST

Cost of parts: Not more than $14.00.

Selectivity: Fair.

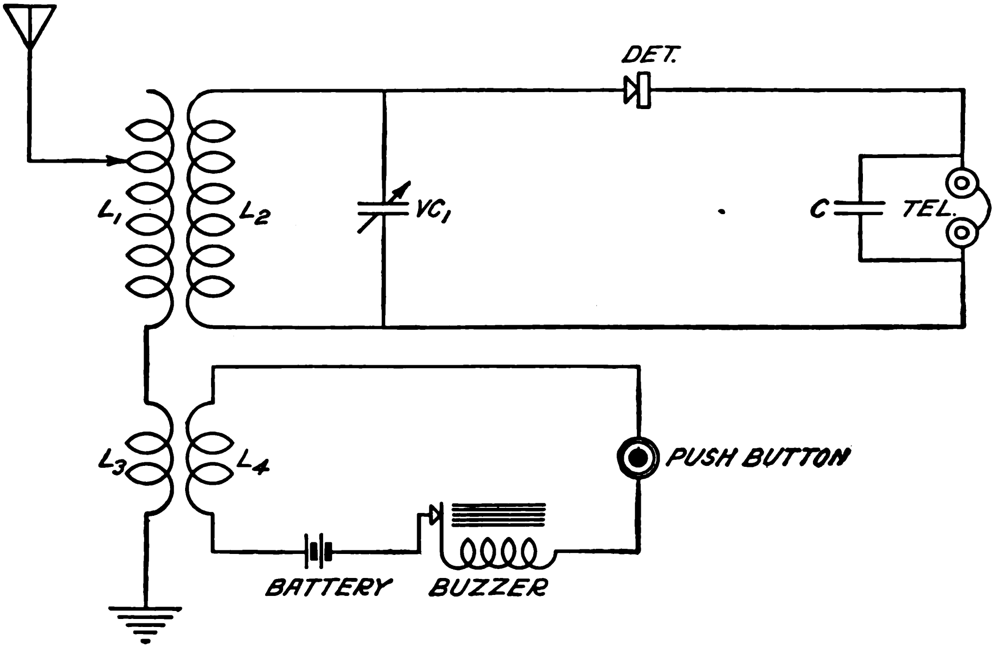
Operation: Simple. The buzzer test simplifies the adjustment of the crystal detector.

Ease of construction: Not difficult. The whole set can be mounted on a board and wired up ready for use in an hour or so.

Approximate range: 15 miles.

Outstanding feature: A simple set for a young beginner to help him obtain his first knowledge of radio.

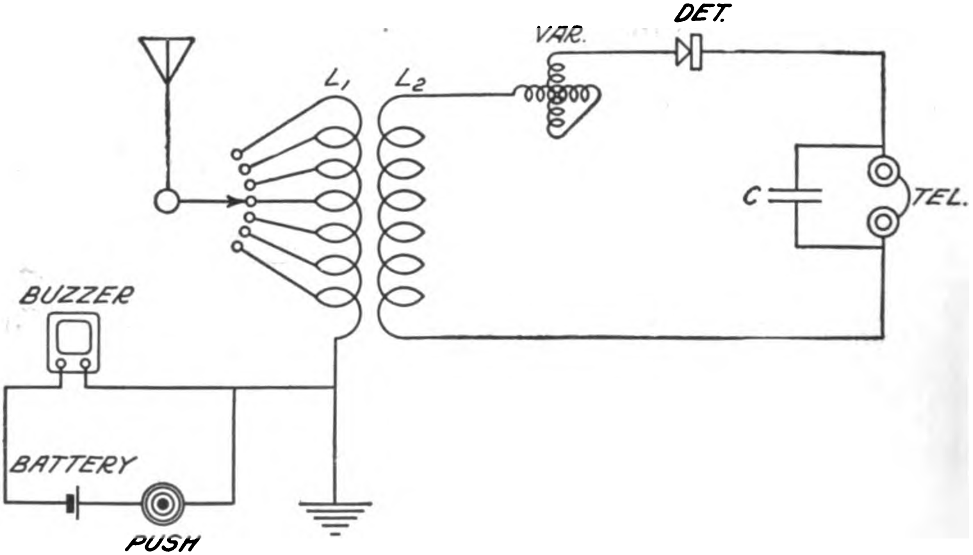
CRYSTAL RECEIVER WITH INDUCTIVELY-COUPLED BUZZER TEST



Cost of parts: Not more than $20.00.
Selectivity: Good.
Operation: Easy.
Construction: Very easy to make.*

Approximate range: 15 miles.
Outstanding feature: A really good buzzer test for setting the crystal for maximum sensitivity.

*(See POPULAR RADIO, *February, 1924, page 188, for constructional details.)*

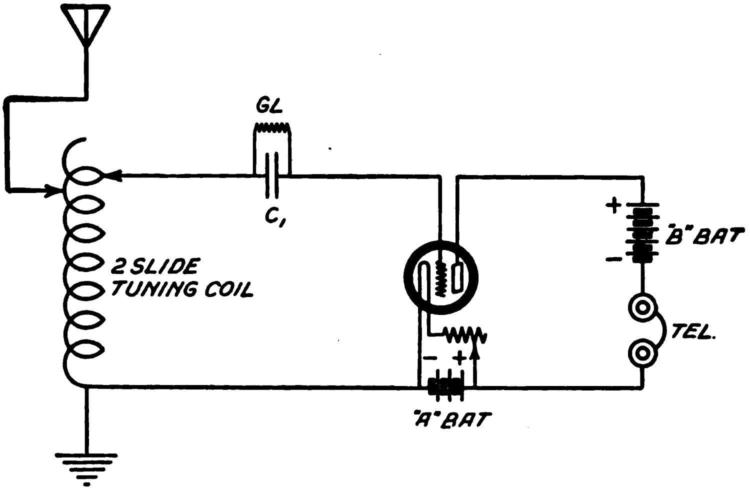


THE INDUCTIVELY-TUNED CRYSTAL CIRCUIT

Cost of parts: Not more than $15.00.
Selectivity: Good.
Operation: Fairly simple. The antenna circuit is tuned by a tapped switch, the secondary by a variometer and the coupling is varied by rotating the secondary coil of the vario-coupler.

Ease of construction: Easy to build.
Approximate range: 15 miles.
Outstanding features: The set is sharp to tune on account of the loose coupling that can be employed, and it has a test buzzer which is a great help in setting the crystal in adjustment.

One-tube Circuits



THE TWO-SLIDE TUNER, NON-REGENERATIVE CIRCUIT

Cost of parts: Not more than $13.00 (*Note:* The costs of tubes and batteries are considered "extras" and are not included in the costs given in these descriptions).

Selectivity: Fair.

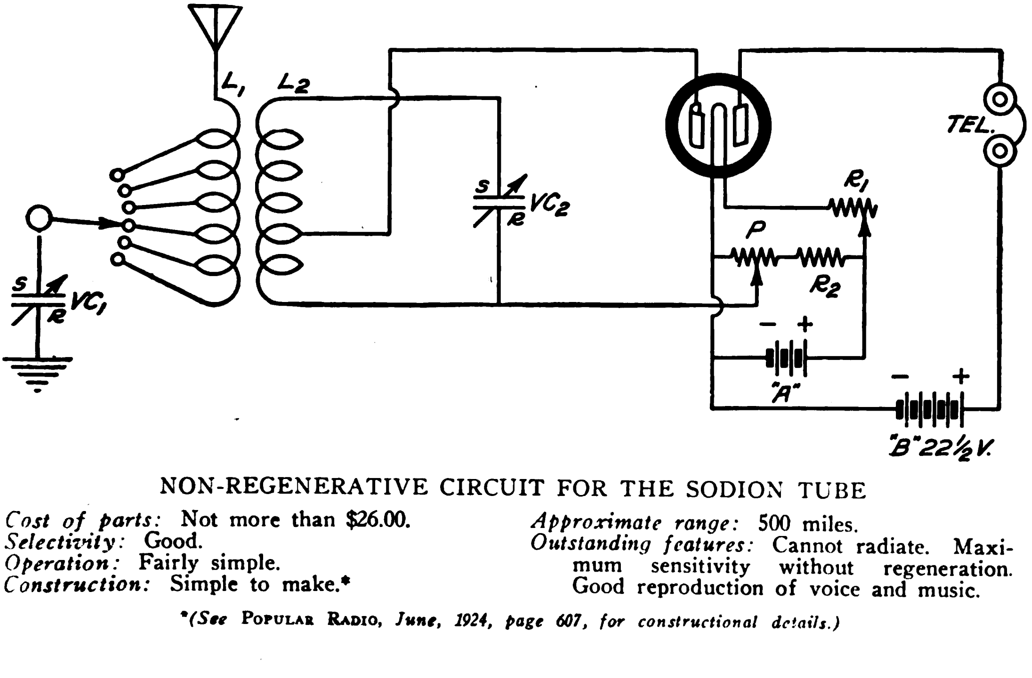
Operation: An easy vacuum-tube circuit to tune. There is one slider for the antenna circuit and one for the secondary circuit. The only adjustment for the detector is the rheostat, which controls the brilliancy of the filament.

Ease of construction: Extremely simple.*

Approximate range: 100 miles.

Outstanding features: This is probably the next set for the beginner to build after he has experimented with the crystal receiver and found out how it works. This circuit will give good clear signals. It cannot re-radiate.

**(See* Popular Radio, *October, 1922, page 148, for constructional details.)*



NON-REGENERATIVE CIRCUIT FOR THE SODION TUBE

Cost of parts: Not more than $26.00.

Selectivity: Good.

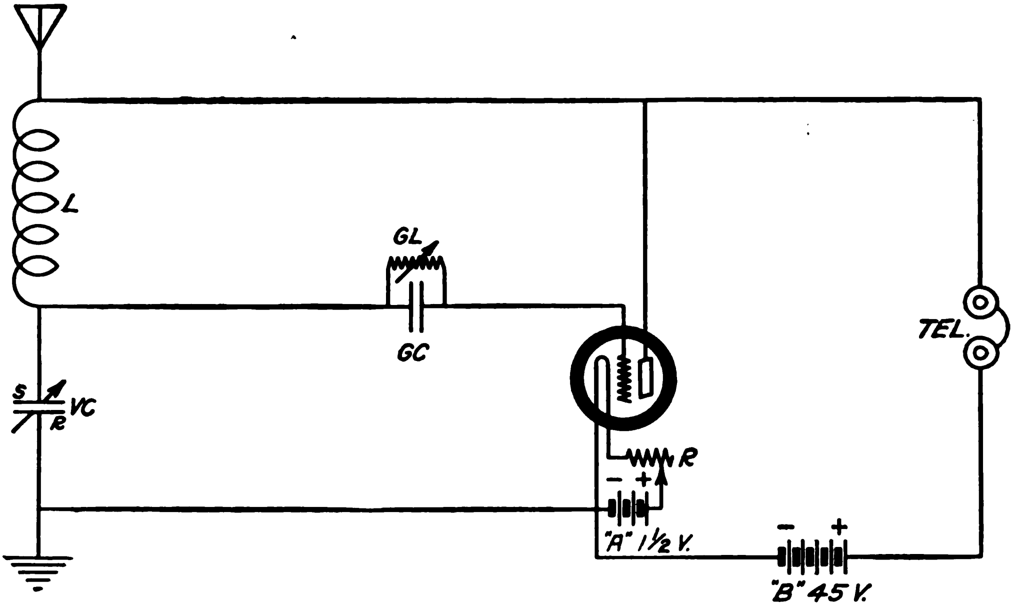
Operation: Fairly simple.

Construction: Simple to make.*

Approximate range: 500 miles.

Outstanding features: Cannot radiate. Maximum sensitivity without regeneration. Good reproduction of voice and music.

**(See* Popular Radio, *June, 1924, page 607, for constructional details.)*



MODIFIED COLPITTS CIRCUIT FOR RECEIVING

Cost of parts: Not more than $14.00.

Selectivity: Fair.

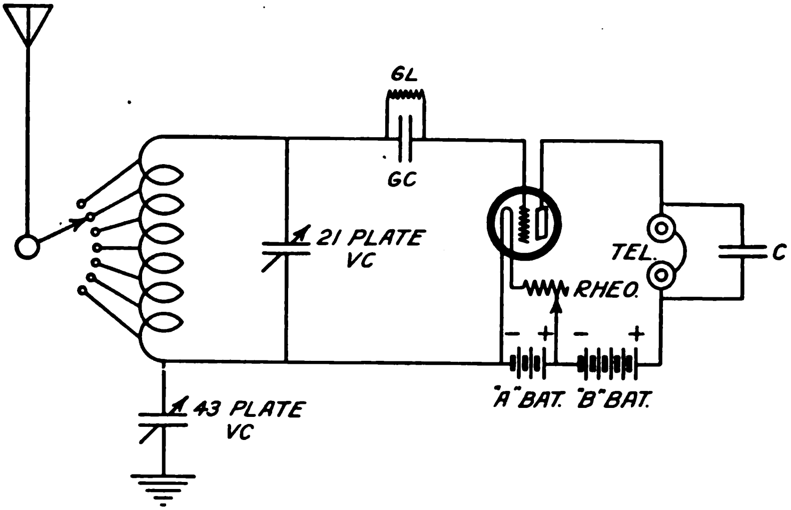
Operation: Simple. The variable condenser changes the wavelength and the filament rheostat controls regeneration.

Construction: Easy to make.*

Approximate range: 500 miles.

Outstanding features: Only a single, simple control for tuning. The filament rheostat should not be turned up too high or the set will radiate badly.

*(See POPULAR RADIO, *May, 1924, page 439, for constructional details.)*



CONDUCTIVELY-COUPLED, CONDENSER-TUNED, VACUUM-TUBE CIRCUIT

Cost of parts: Not more than $20.00 (*Note:* The cost of tubes and batteries is not included in the cost given in these descriptions).

Selectivity: Fair.

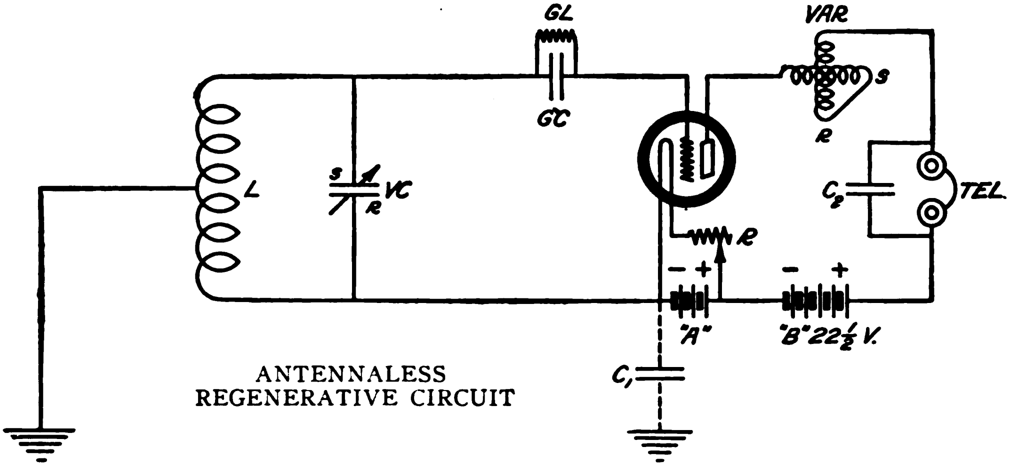
Operation: Simple.

Construction: Easy to build, and a good circuit for the beginner to try.*

Approximate range: 100 miles.

Outstanding feature: The best set for the beginner to learn the operating characteristics of the vacuum tube with.

*(See POPULAR RADIO, *January, 1923, page 61, for constructional details.)*

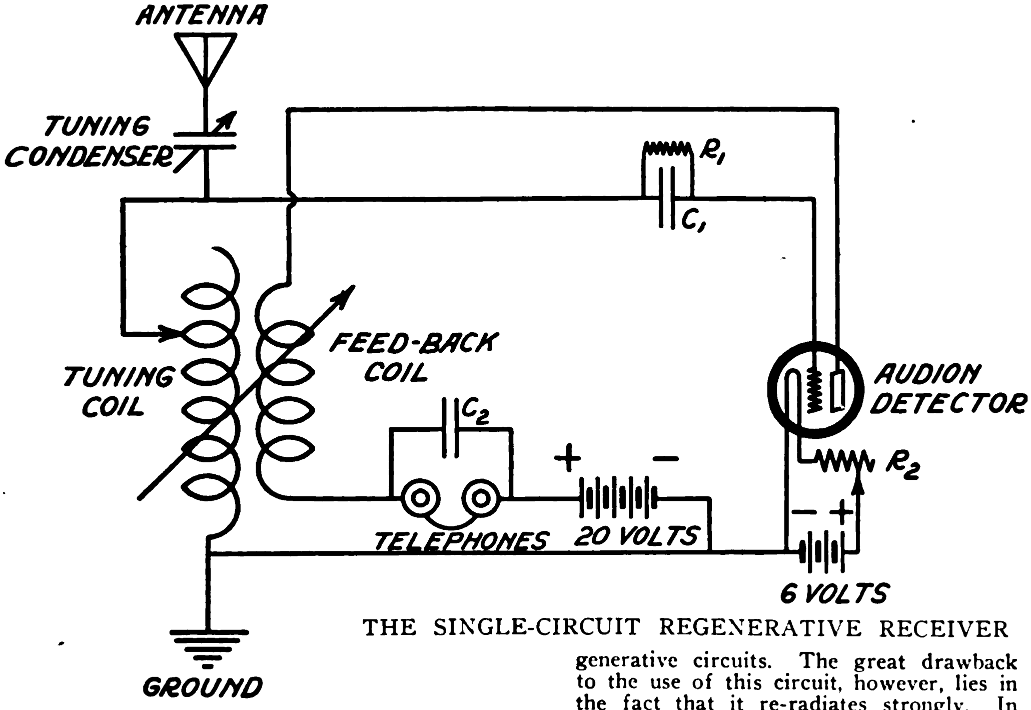


ANTENNALESS
REGENERATIVE CIRCUIT

Cost of parts: Not more than $21.00.
Selectivity: Excellent.
Operation: Very simple. One control for wavelength and one for regeneration.

Ease of construction: Not difficult to make.*
Approximate range: 20 miles.
Outstanding features: Works without an antenna. Reduction in static. Fine for local reception.

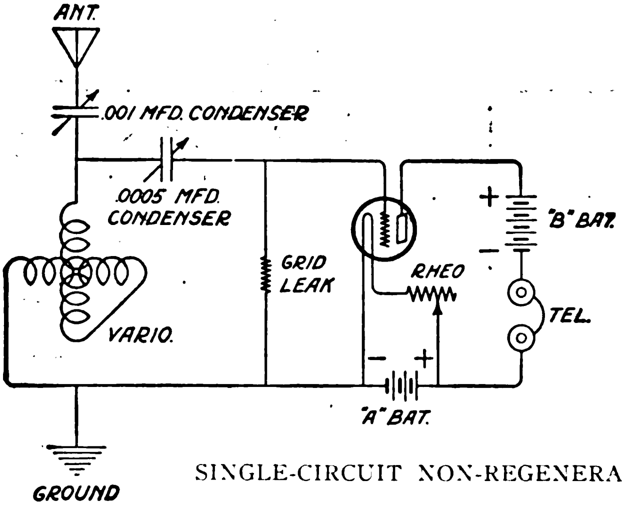
(See Popular Radio, November, 1923, page 372, for constructional details.)



THE SINGLE-CIRCUIT REGENERATIVE RECEIVER

Cost of parts: Not more than $20.00.
Selectivity: Poor.
Operation: Simple.
Ease of construction: Not complicated.*
Approximate range: 500 miles.
Outstanding features: Easy to build and easy to operate; much simpler than most regenerative circuits. The great drawback to the use of this circuit, however, lies in the fact that it re-radiates strongly. In other words, while it is being used for receiving, it generates radio-frequency currents in the antenna system which cause radio waves to be sent out to produce interference in other receiving sets in the neighborhood. In the hands of an expert operator this might not happen.

(See Popular Radio, November, 1922, page 192, for constructional details.)



SINGLE-CIRCUIT NON-REGENERATIVE SET

Cost of parts: Not more than $22.00.

Selectivity: Only fair. (This modification is a little more selective than the one shown on page 50 of the January, 1923, issue.)

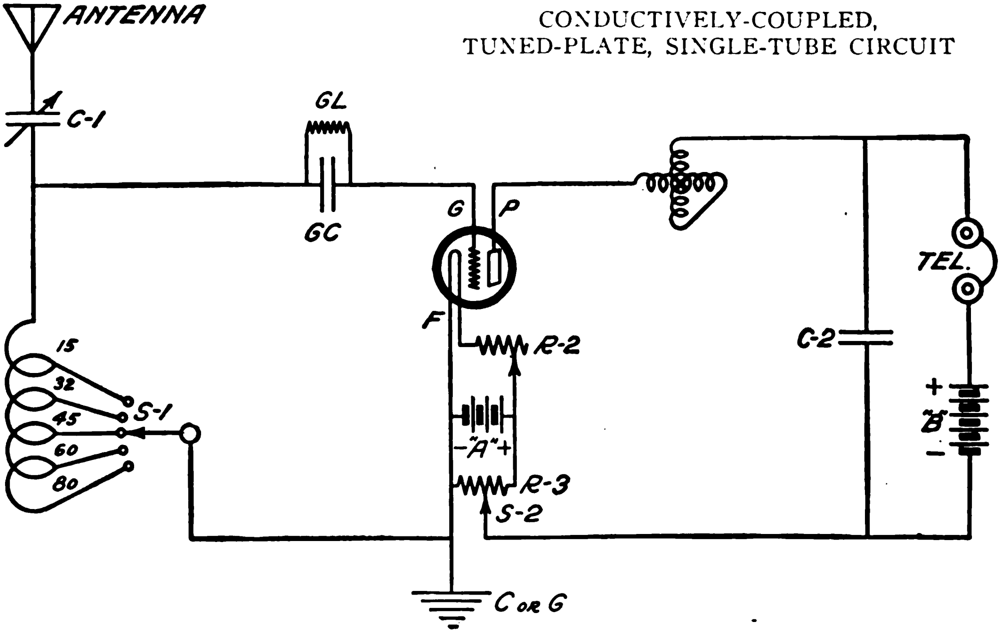
Operation: Simple. The variometer and one of the variable condensers tune the antenna, and the variometer and the other variable condenser control the grid-circuit tuning.

Construction: Not complicated.*

Approximate range: 100 miles.

Outstanding feature: A non-re-radiating, single-circuit receiver for reception of local signals.

*(*See* Popular Radio, *January, 1923, page 59, for constructional details.*)



CONDUCTIVELY-COUPLED, TUNED-PLATE, SINGLE-TUBE CIRCUIT

Cost of parts: Not more than $23.00.

Selectivity: Only fair.

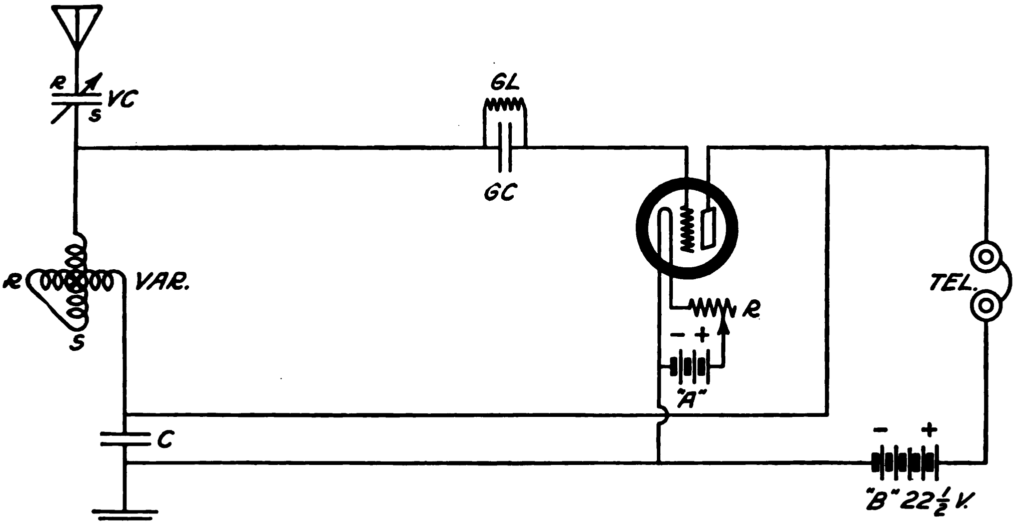
Operation: Simple. A variable condenser is used for wavelength control and a variometer is used in the plate circuit to control regeneration.

Ease of construction: Not complicated.*

Approximate range: 500 miles.

Outstanding features: This modification will tune a little better than the straight single-circuit set, and can be kept in more stable operation by means of the potentiometer. The set is guilty, however, of permitting interfering re-radiation in the hands of the inexperienced operator.

*(*See* Popular Radio, *June, 1923, page 430, for constructional details.*)



SIMPLE ONE-TUBE REGENERATIVE RECEIVER

Cost of parts: Not more than $19.00.

Selectivity: Fair.

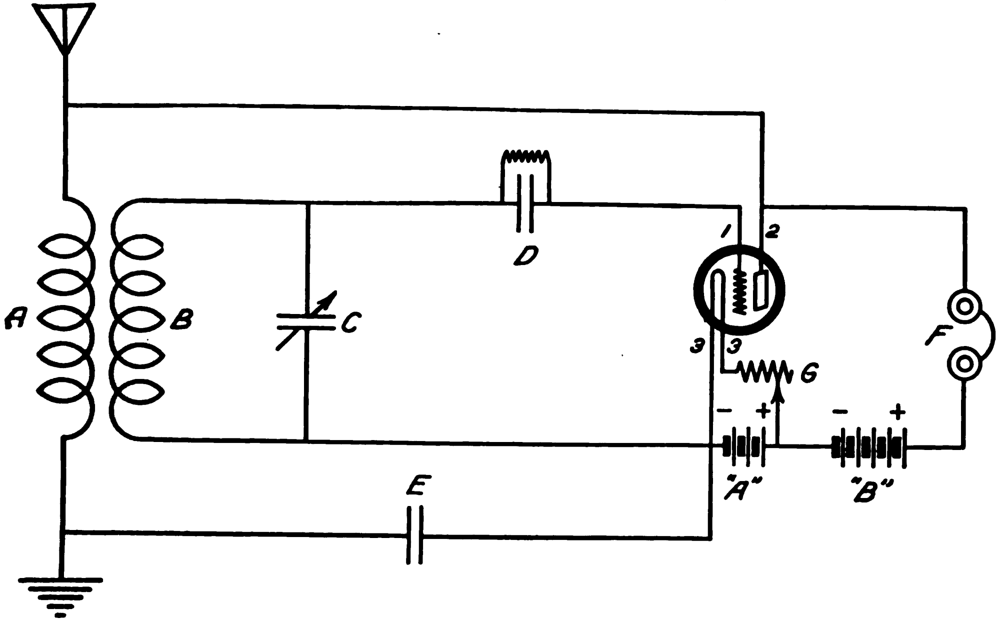
Operation: Simple to tune. Wavelength is controlled by the variable condenser and the variometer. Regeneration is controlled by the filament rheostat.

Construction: Extremely simple.*

Approximate range: 500 miles.

Outstanding features: This is a simple set to build and operate. It will give good results in the hands of beginners. But the filament rheostat should not be turned up too high or the set will radiate badly.

(See POPULAR RADIO, February, 1924, page 197, for constructional details.)



THE MAN-DAY SINGLE-CONTROL REGENERATIVE CIRCUIT

Cost of parts: Not more than $12.00.

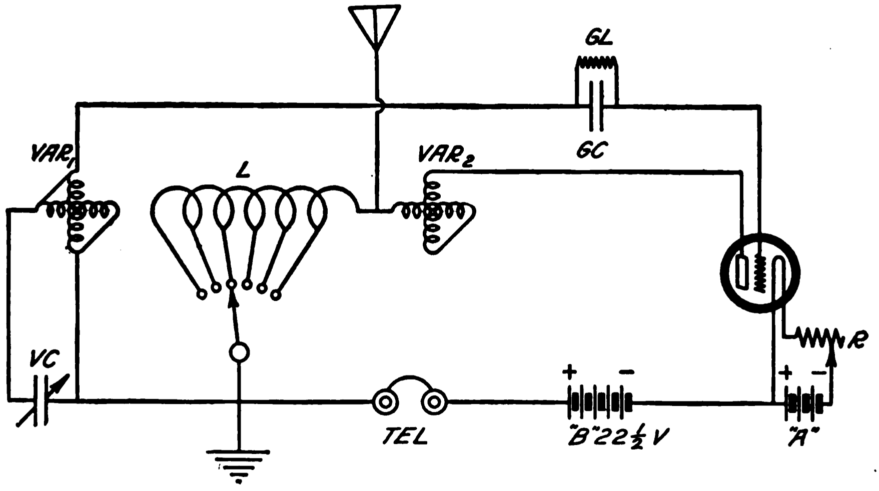
Selectivity: Excellent.

Operation: Very easy. Only one control for wavelength. Regeneration is adjusted with the filament rheostat.

Ease of construction: Simple.

Approximate range: 500 miles.

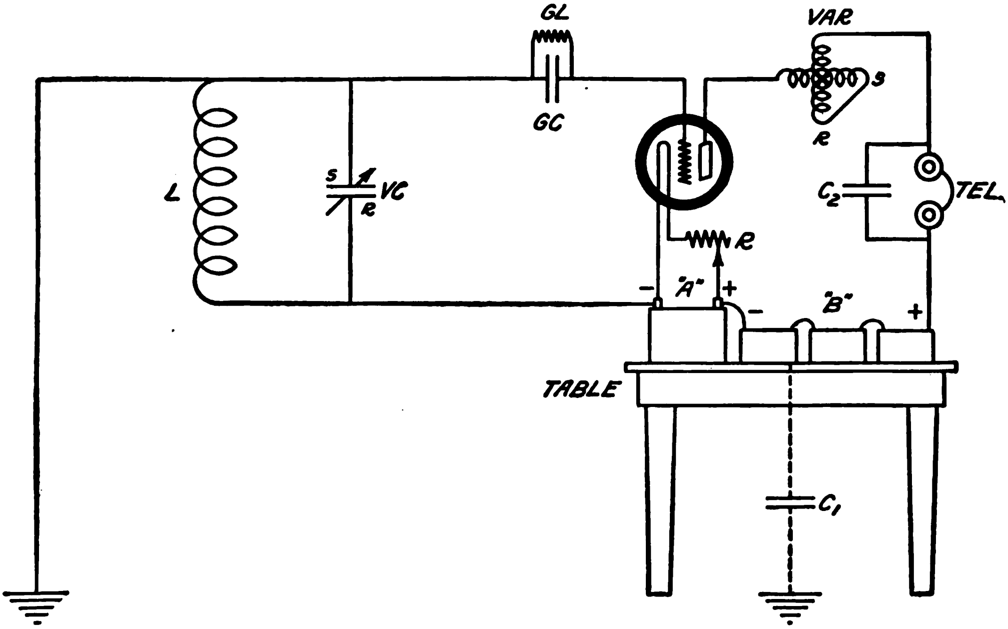
Outstanding features: This is the simplest regenerative circuit to tune. It is very selective and costs but little.



NOVEL VARIOMETER HOOK-UP

Cost of parts: Not more than $24.00.
Selectivity: Fair.
Operation: Rather complicated.
Construction: Just an ordinary acquaintance with tools and some experience in wiring up the circuit is necessary.*
Approximate range: 800 miles.
Outstanding features: Strong signals from one tube. The set will readily radiate, unless carefully handled. For this reason it is a menace to a neighbor's reception, in the hands of a novice.

*(See POPULAR RADIO, *August, 1923, page 176, for constructional details.)*



A REGENERATIVE SET FOR RECEPTION WITH A GROUND ONLY

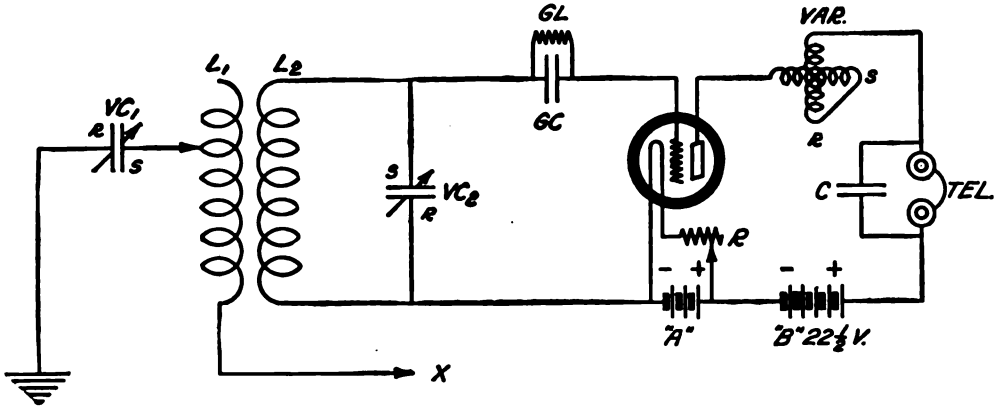
Cost of parts: Not more than $23.00.

Selectivity: Excellent.

Operation: Easy to tune. There are only two controls, the variable condenser for wavelength, and the variometer for regeneration.

Construction: Very simple to make.*
Approximate range: 25 miles.
Outstanding feature: This is a good type of receiver for local reception where the conditions make impossible the erection of an outside antenna.

*(See POPULAR RADIO, *November, 1923, page 372, for constructional details.)*



A SIMPLE REGENERATIVE RECEIVER FOR USE WITH TWO GROUNDS

Cost of parts: Not more than $30.00.

Selectivity: Excellent.

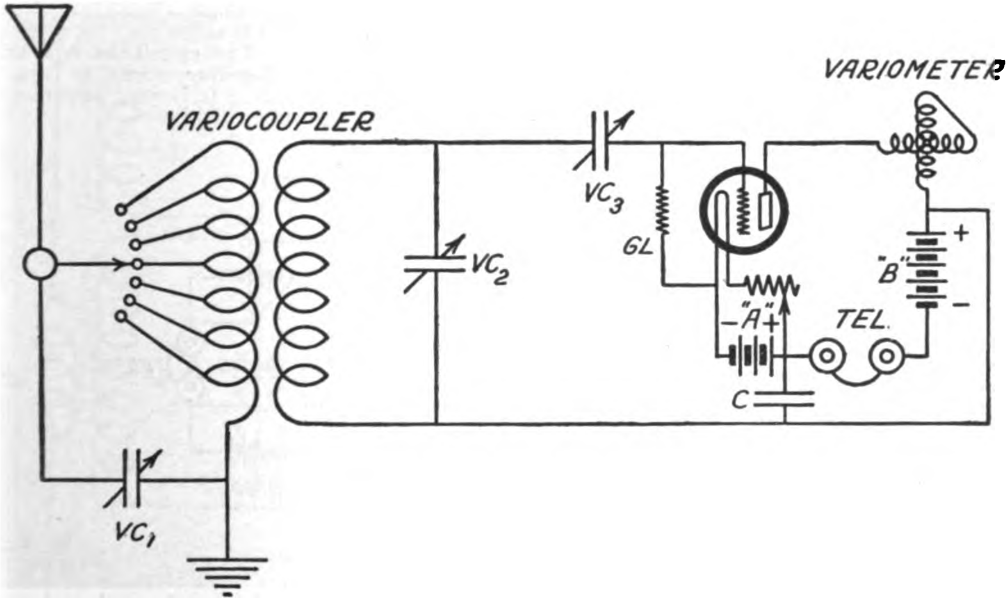
Operation: Not especially complicated. The ground circuit is tuned by means of a variable condenser; likewise the secondary circuit. The plate circuit of the detector tube is tuned by means of a variometer and this controls regeneration.

Construction: Not complicated.*

Approximate range: Local.

Outstanding feature: No antenna is necessary. Just use two grounds; one may be the water pipe and the other the radiator system or the gas pipes.

*(See POPULAR RADIO, *November, 1923, page 373, for constructional details.)*



TUNED-PLATE ULTRA-AUDION CIRCUIT WITH FINER CONTROLS

Cost of parts: Not more than $34.00.

Selectivity: Excellent.

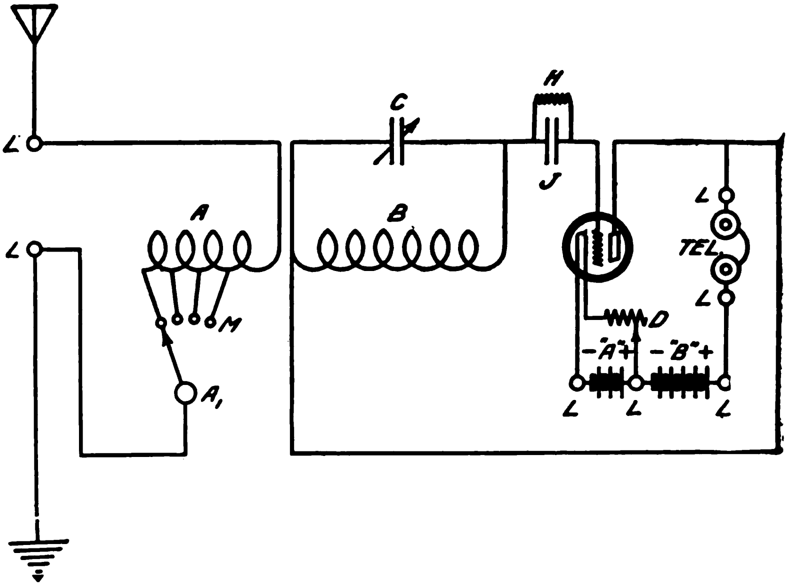
Operation: Fairly simple. This adaptation of this circuit contains variable tuning elements such as a variable grid-condenser, variable grid-leak, and a variable condenser in the antenna circuit which will enable the more experienced operator to get maximum results out of the receiver.

Ease of construction: Just an ordinary acquaintance with tools and some ability in wiring up the circuit are necessary.*

Approximate range: 1,000 miles.

Outstanding features: A real set for the advanced man who wants selectivity and sensitivity at reasonable cost.

*(See POPULAR RADIO, *February, 1923, page 142, for constructional details.)*



SPECIAL ULTRA-AUDION CIRCUIT

Cost of parts: Not more than $12.00 (*Note:* The costs of tubes and batteries are considered "extras" and are not included in the costs given in these descriptions).

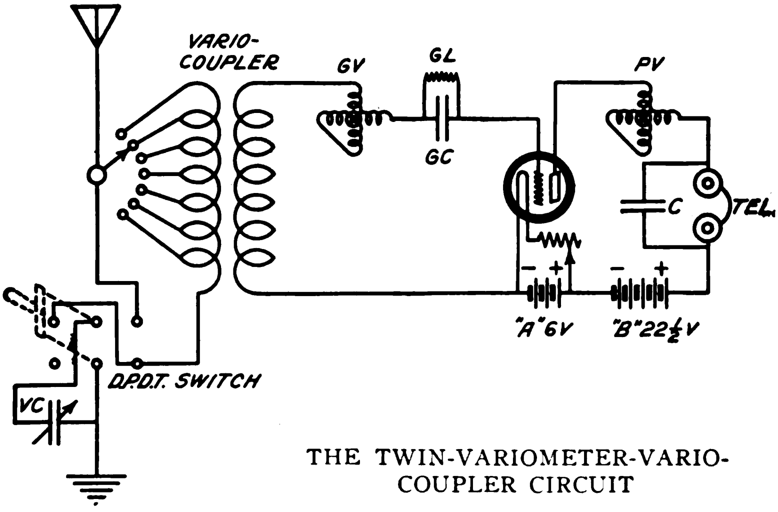
Selectivity: Excellent.

Operation: Very easy. When the switchpoint A1 is adjusted for the antenna, there is only one control for wavelength. The regeneration is controlled by the filament rheostat.

Ease of construction: Simple.

Approximate range: 500 miles.

Outstanding features: This circuit shares first place with the Man-Day circuit in simplicity of operation. It is very selective, and costs but little.



THE TWIN-VARIOMETER-VARIO-COUPLER CIRCUIT

Cost of parts: Not more than $30.00.

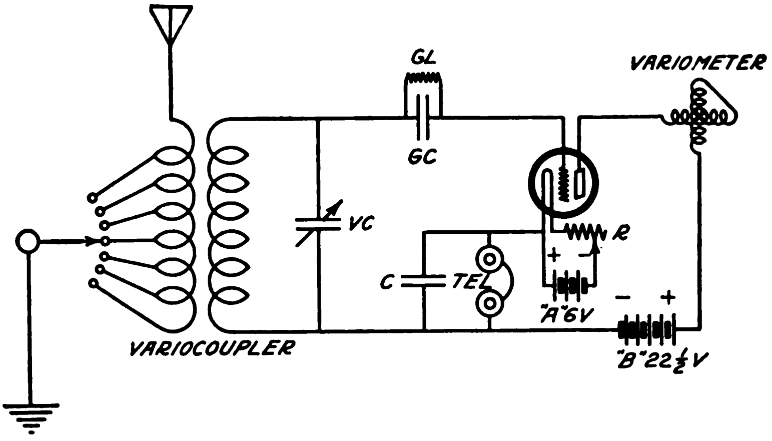
Selectivity: Good.

Operation: Requires considerable skill which can be acquired in a couple of months of experimenting with the tuning.

Ease of construction: Just an ordinary acquaintance with tools but some electrical ability in wiring up the circuit is necessary.

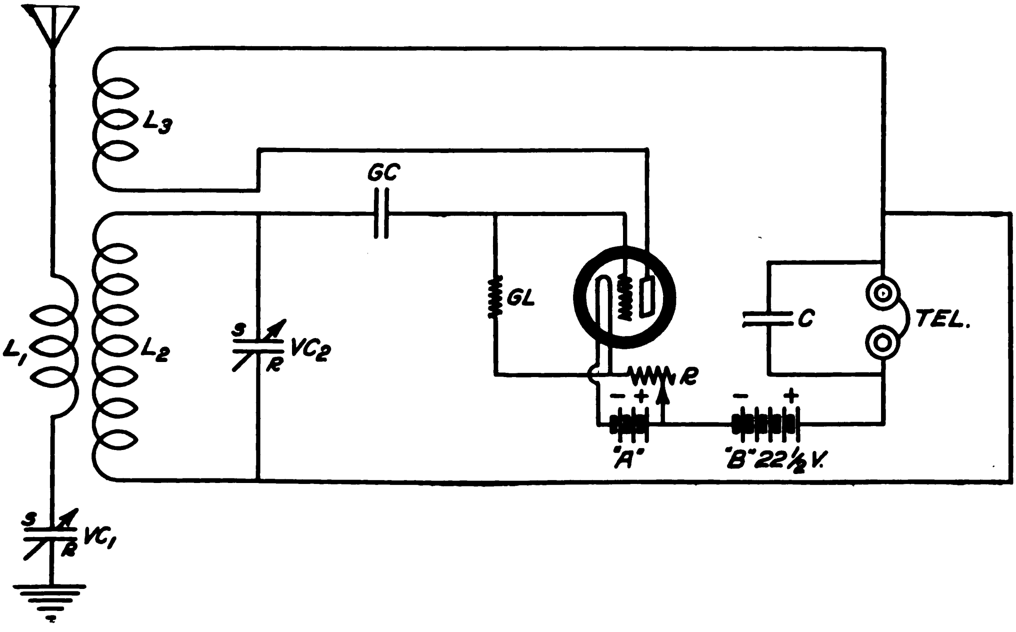
Approximate range: 500 miles.

Outstanding features: This was the first well-known short-wave regenerative receiver and it has been found reliable and probably has been more used than any other type of receiver in the past.



THE COMBINATION TUNED-PLATE, ULTRA-AUDION CIRCUIT

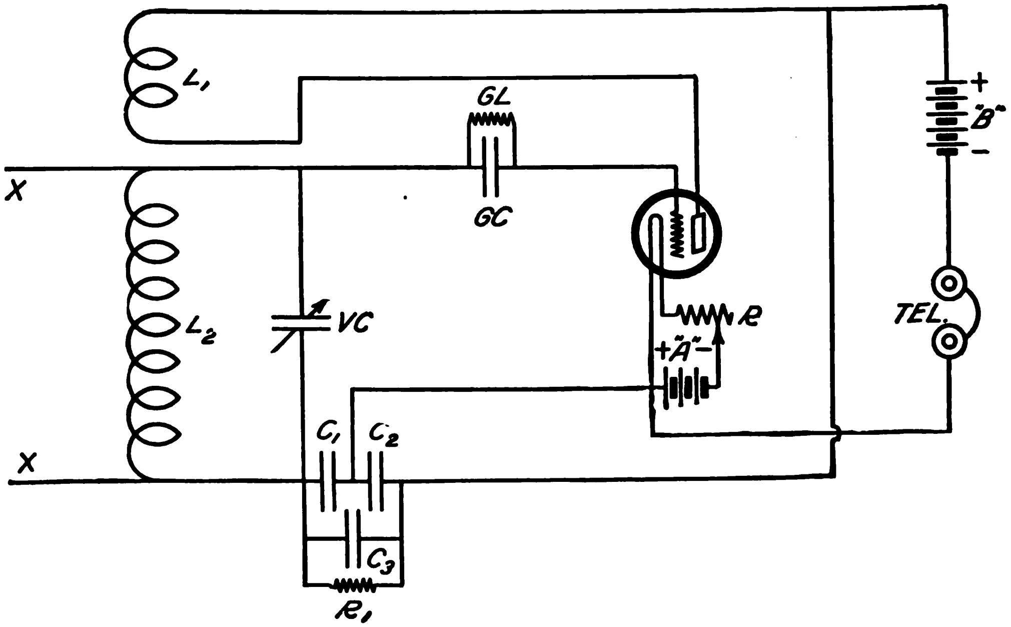
Cost of parts: Not more than $25.00 (*Note:* The cost of tubes and batteries is considered "extra," and is not included in the cost given in these descriptions).
Selectivity: Excellent.
Operation: Requires considerable skill which can be acquired in a couple of months of experimenting with the tuning.
Ease of construction: Just an ordinary acquaintance with tools, but some electrical ability in wiring up the circuit is necessary.
Approximate range: 500 miles.
Outstanding features: Exceptionally suitable for DX amateur work on CW. Tuning is very sharp and easy when it is learned correctly.



THREE-CIRCUIT TUNER FOR SHORT-WAVE RECEPTION

Cost of parts: Not more than $27.00.
Selectivity: Very good.
Operation: Not very hard to tune when the operator has worked with the set for a week or so.
Construction: Not difficult to make.*
Approximate range: 500 miles for telephony; 1,000 miles for CW reception.
Outstanding features: For work below 200 meters. For short-wave broadcast reception and amateur CW reception.

*(*See* POPULAR RADIO, *August, 1924, page 183, for constructional details.*)



FLEWELLING MODIFIED SUPER-REGENERATIVE CIRCUIT

Cost of parts: Not more than $22.00.

Selectivity: Fair (on outdoor antenna). Good (on loop).

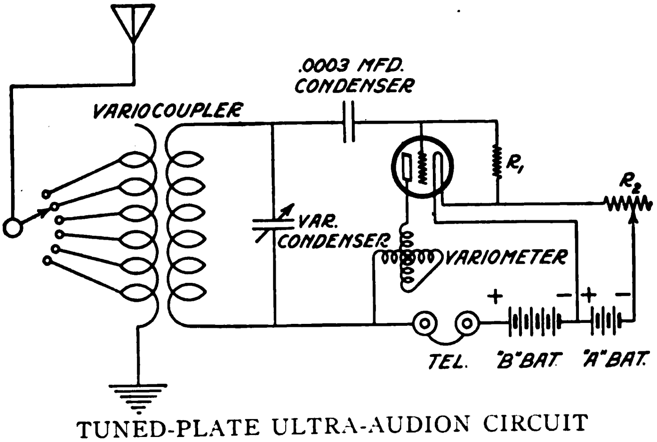
Operation: Not hard to operate when the circuit has once been adjusted properly. When used on an outdoor antenna, however, it is liable to produce bad interference to neighbors, due to re-radiation.

Ease of construction: Easy to make but not easy to get adjusted right.*

Approximate range: Local (on loop). 500 miles (on an outdoor antenna).

Outstanding features: Simplest super-regenerative circuit. Can be made to operate a loudspeaker on one tube. This is only true when all conditions are satisfied. Actually, many experimenters do not get very good results on account of some mistakes they have made and have failed to locate. Reception is accompanied with a high-pitched whistle.

(See Popular Radio, *May, 1923, page 393, for constructional details.)*



TUNED-PLATE ULTRA-AUDION CIRCUIT

Cost of parts: Not more than $23.00 (*Note:* The cost of tubes and batteries is considered "extra" and is not included in the cost given in these descriptions).

Selectivity: Excellent.

Operation: Fairly simple.

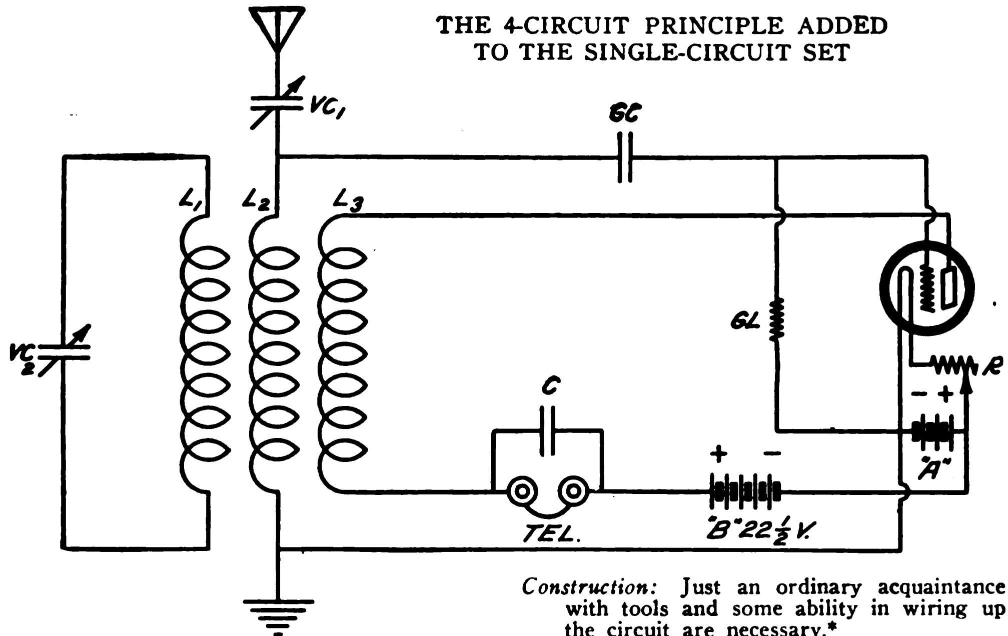
Ease of construction: Not complicated.*

Approximate range: 1,000 miles.

Outstanding features: Noted for DX, amateur and broadcast reception and for its exceptionally sharp tuning.

(See Popular Radio, *September, 1922, page 62, for constructional details.)*

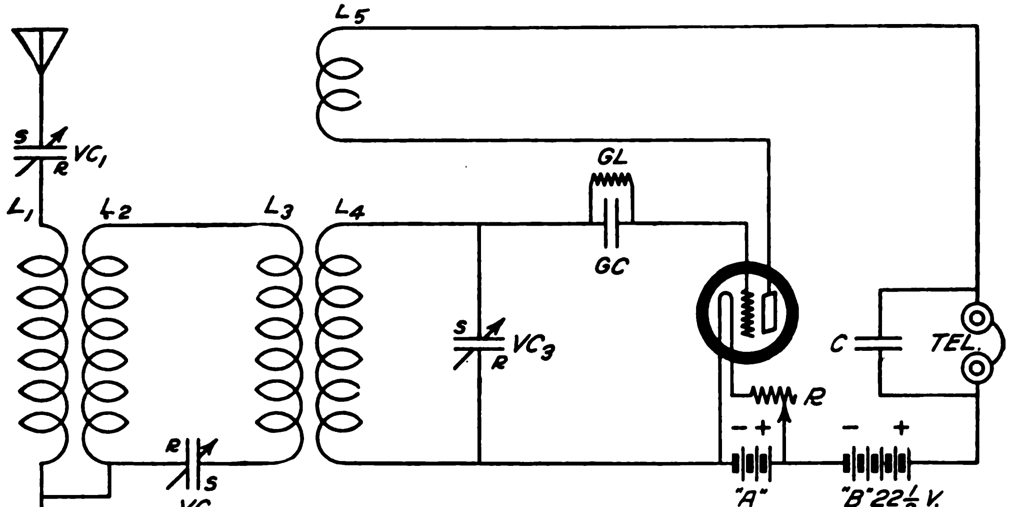
THE 4-CIRCUIT PRINCIPLE ADDED TO THE SINGLE-CIRCUIT SET



Cost of parts: Not more than $25.00.
Selectivity: Fair.
Operation: The extra circuit, comprising the condenser VC2 and the coil L1, gives a much better control of regeneration than in the conventional circuit.

Construction: Just an ordinary acquaintance with tools and some ability in wiring up the circuit are necessary.*
Approximate range: 500 miles.
Outstanding feature: The added circuit will give stability to the control of regeneration so that the circuit will not burst into oscillation and cause a violent disturbance in neighbors' receivers.

*(See POPULAR RADIO, *October, 1923, page 325, for constructional details.)*

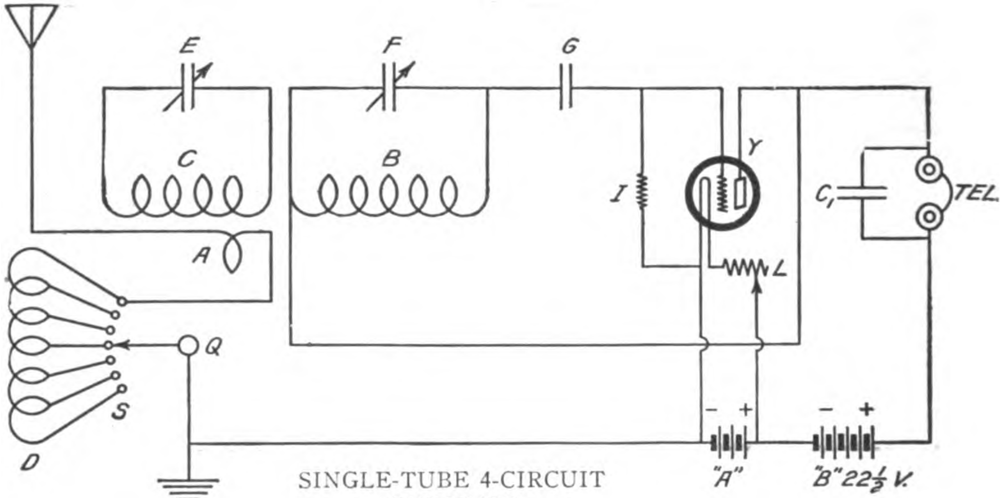


A REGENERATIVE RECEIVER WITH AN INTERMEDIATE CIRCUIT TO REDUCE RADIATION

Cost of parts: Not more than $30.00.
Selectivity: Very good.
Operation: Rather complicated.
Construction: Just an ordinary acquaintance with tools and some ability in wiring up the electrical circuit are necessary.*

Approximate range: 500 to 1,000 miles.
Outstanding features: The receiving system used here makes use of an intermediate, resonant circuit for loosening the coupling between the antenna circuit and the grid circuit so that radiation will be prevented.

*(See POPULAR RADIO, *March, 1924, page 292, for constructional details.)*



SINGLE-TUBE 4-CIRCUIT RECEIVER

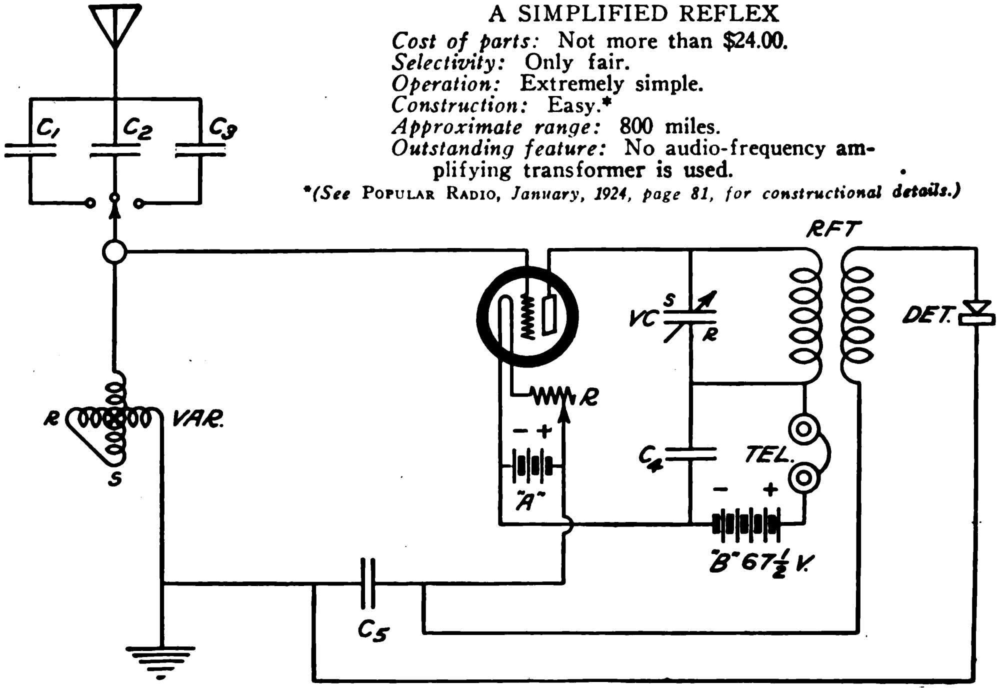
Cost of parts: Not more than $24.00.
Selectivity: Excellent.
Operation: Simple. The condenser C1 should be of the correct value to put the set into stable condition and then the condenser E is adjusted so that the circuit is just on the highly regenerative point. All tuning is then accomplished with the condenser F and the antenna switch Q.
Ease of construction: Not complicated. Be sure that the best parts are obtained and the results will exceed expectations. Poor parts render the circuit useless.
Approximate range: 1,000 miles.
Outstanding features: The regeneration is independent of wavelength. The selectivity and sensitivity of this type of receiver are noteworthy.

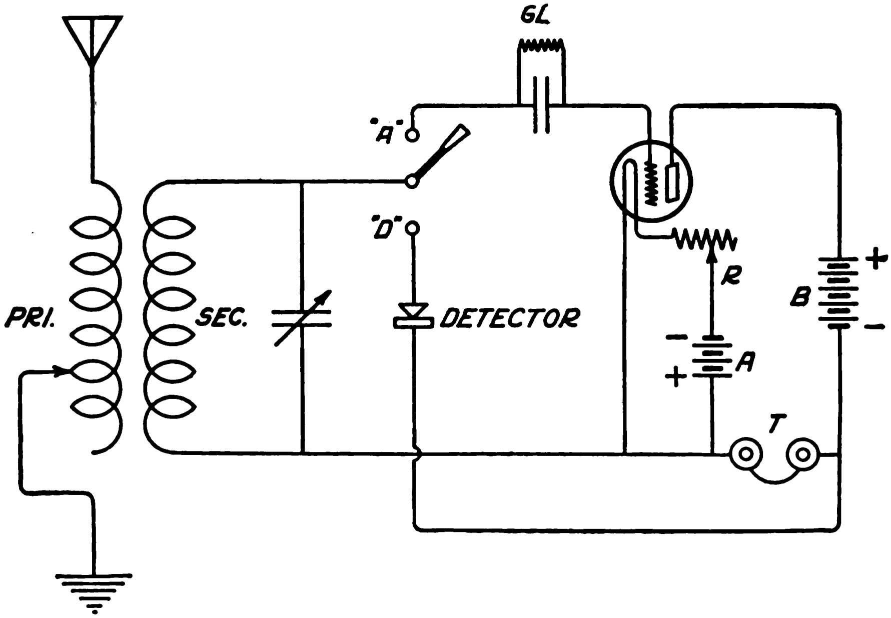
One-tube and Crystal Circuits

A SIMPLIFIED REFLEX

Cost of parts: Not more than $24.00.
Selectivity: Only fair.
Operation: Extremely simple.
Construction: Easy.*
Approximate range: 800 miles.
Outstanding feature: No audio-frequency amplifying transformer is used.

*(See POPULAR RADIO, *January, 1924, page 81, for constructional details.)*





COMBINATION CRYSTAL AND VACUUM-TUBE SET

Cost of parts: Not more than $21.00.

Selectivity: Fairly good.

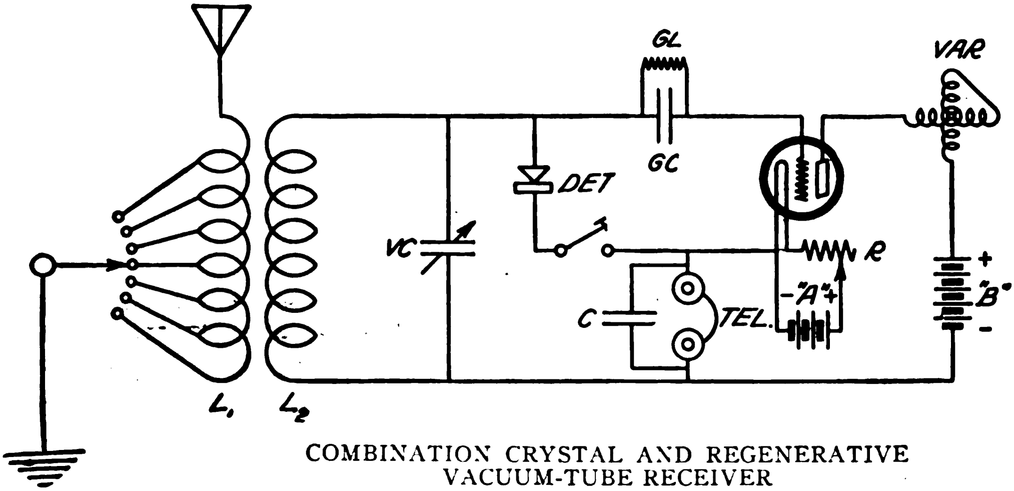
Operation: Very simple.

Ease of construction: Simple to make.*

Approximate range: 15 miles on the crystal detector. 100 miles on the vacuum-tube detector.

Outstanding features: Here is the circuit for the man who already has a crystal receiver and wishes to find out what the vacuum-tube detector will do for him in the way of increased signals. The crystal may be used for strong local stations and the vacuum tube may be used for the more distant and weaker ones.

**(See* Popular Radio, *July, 1922, page 222, for information about use.)*



COMBINATION CRYSTAL AND REGENERATIVE VACUUM-TUBE RECEIVER

Cost of parts: Not more than $27.00.

Selectivity: Good (with crystal). Excellent (with vacuum tube).

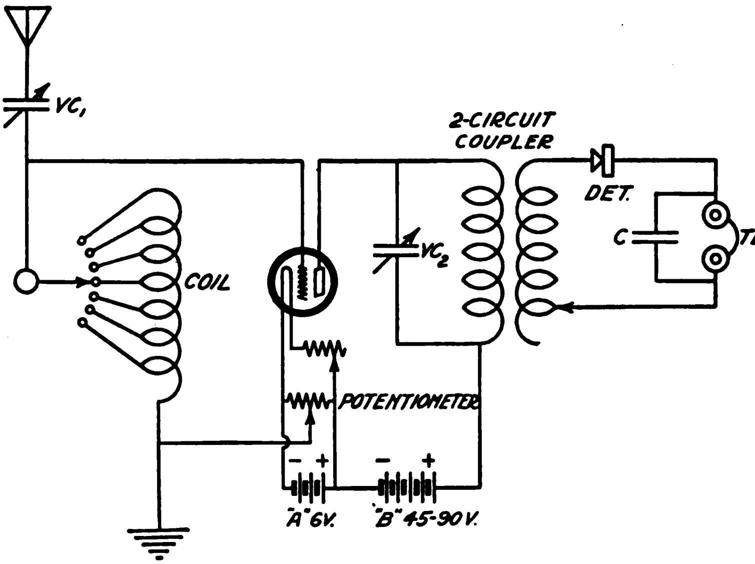
Operation: Simple.

Construction: Not complicated.*

Approximate range: 15 miles (with crystal); 500 miles (with vacuum tube).

Outstanding feature: By simply throwing a switch, the operator can listen in with a crystal detector for local reception, or can use the vacuum tube for distant stations.

**(See* Popular Radio, *May, 1923, page 397, for constructional details.)*



SINGLE-STAGE RADIO-FREQUENCY AMPLIFIER
WITH CRYSTAL DETECTOR

Cost of parts: Not more than $26.00.

Selectivity: Fairly good.

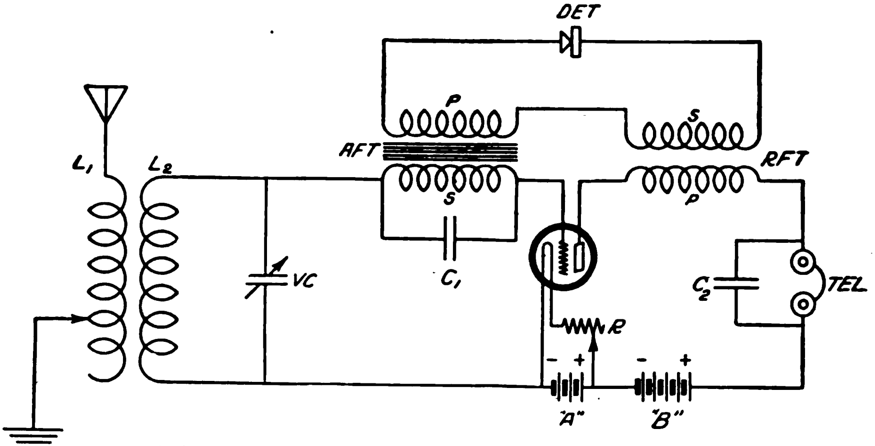
Operation: Not complicated. There are two controls for antenna wavelength, a variable condenser and a tapped coil. The plate circuit is tuned by a second variable condenser, and the inductance tap on the secondary of the 2-circuit coupler controls the wavelength of the crystal circuit.

Ease of construction: Just an ordinary acquaintance with tools and some ability in wiring up the set are necessary.*

Approximate range: 500 miles.

Outstanding features: Clear, crisp reception. A short antenna may be used (such as an indoor antenna strung behind the picture molding).

**(See Popular Radio, February, 1923, page 142, for constructional details.)*



SINGLE-TUBE AND CRYSTAL REFLEX CIRCUIT

Cost of parts: Not more than $28.00.

Selectivity: Very good.

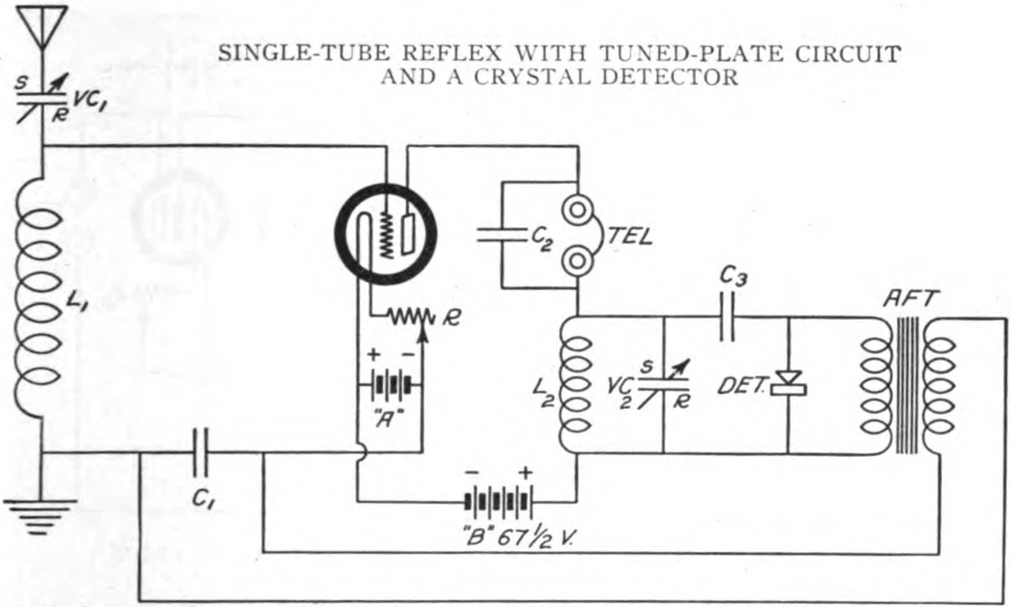
Operation: Fairly simple. Two controls for wavelength and one coupling control are used. The crystal adjustment must be changed for any considerable change in wavelength in order to prevent the circuit from oscillating and still have it retain its maximum signal strength.

Ease of construction: More complicated than the straight regenerative circuits but not beyond the ordinary radio fan's ability.

Approximate range: 1,000 miles.

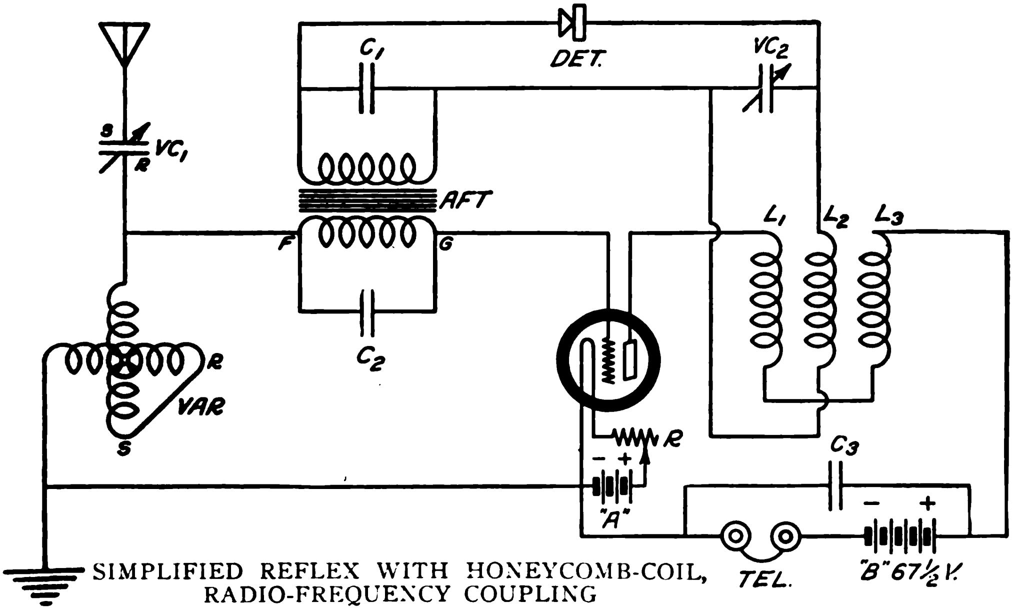
Outstanding feature: Circuit combines radio-frequency, and audio-frequency amplification and regeneration in one tube.

SINGLE-TUBE REFLEX WITH TUNED-PLATE CIRCUIT AND A CRYSTAL DETECTOR



Cost of parts: Not more than $30.00.
Selectivity: Good.
Operation: Easy to tune. The variable condenser in the antenna circuit tunes the input circuit to the tube and the variable condenser in the plate circuit tunes that circuit.
Construction: Just an ordinary acquaintance with tools and some ability in wiring.*
Approximate range: 500 miles.
Outstanding features: A good set for the experimenter who wishes to learn the principles of radio-frequency amplification and of the reflex.

*(See POPULAR RADIO, May, 1924, page 498, for constructional details.)

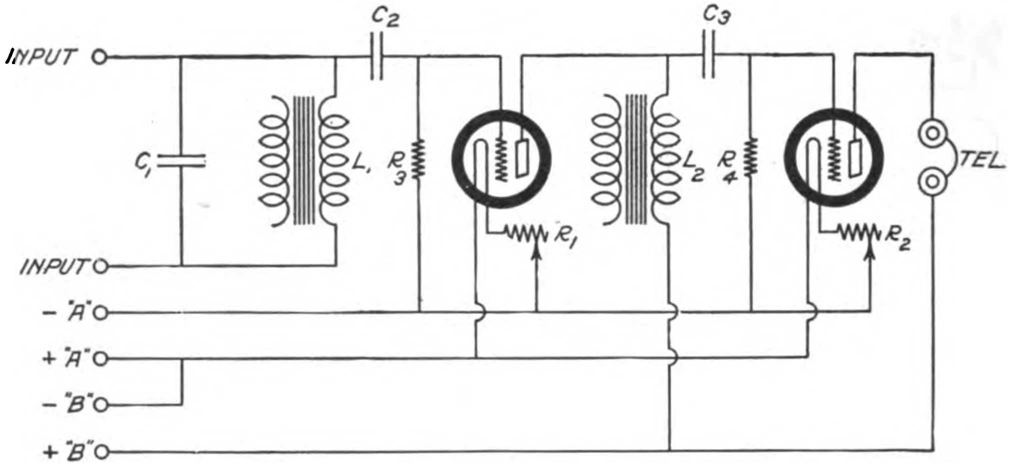


SIMPLIFIED REFLEX WITH HONEYCOMB-COIL, RADIO-FREQUENCY COUPLING

Cost of parts: Not more than $45.00.
Selectivity: Fair.
Operation: Rather difficult.
Construction: Some experience in making sets should be had before trying this one.*
Approximate range: 1,000 miles.
Outstanding features: Will operate a loud-speaker on local stations. Incorporates one stage of radio-frequency amplification and one of audio with only one tube.

*(See POPULAR RADIO, July, 1924, page 105, for constructional details.)

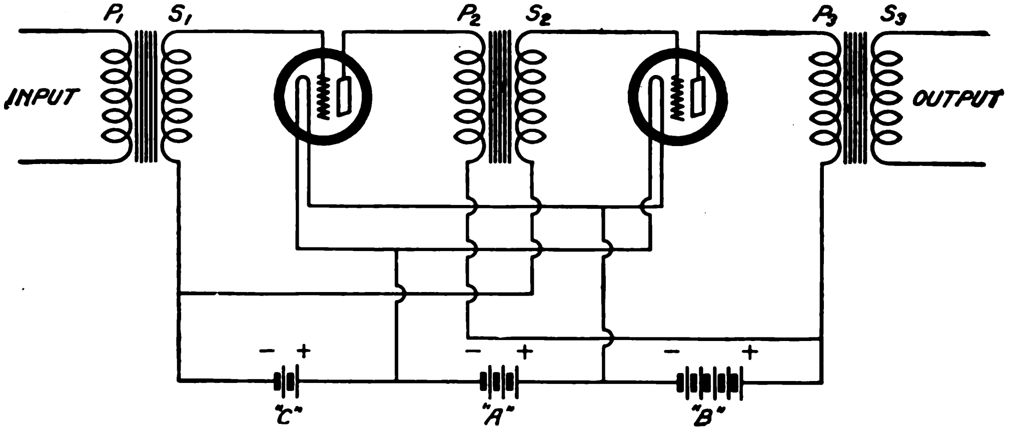
Amplifying Circuits



TWO-STAGE, IMPEDANCE-COUPLED AMPLIFIER MADE FROM FORD SPARK COILS

Cost of parts: Not more than $15.00.
Usage: With headphones or loudspeaker.
Signal strength: Fairly good.
Quality of reproduction: Fairly good.
Construction: Simple.*
Outstanding features: Simple to make and operate, and of low cost, especially if you have same old Ford coils on hand.

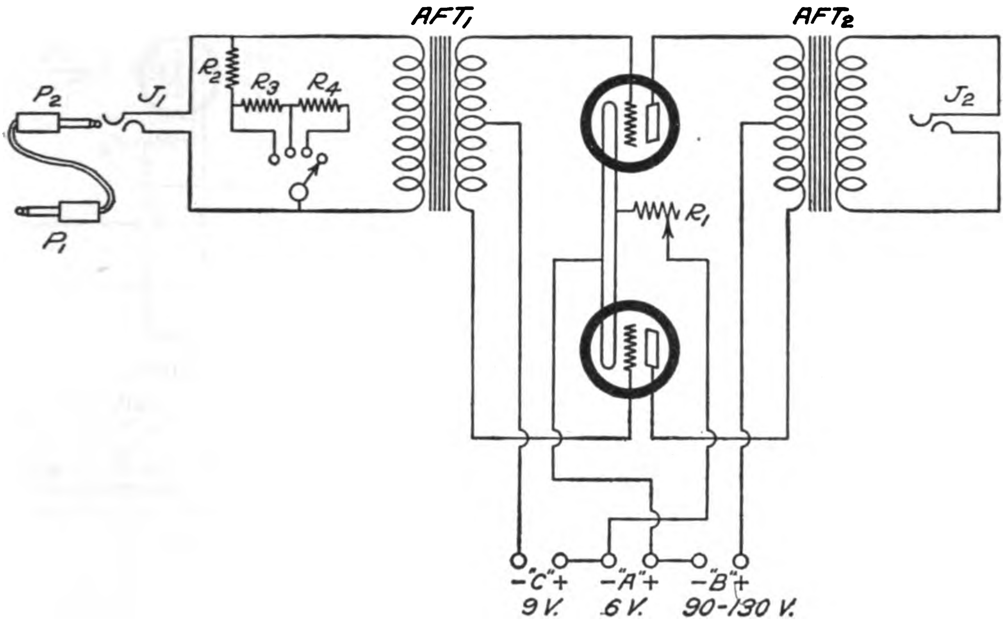
(See Popular Radio, April, 1924, page 417, for constructional details.)



TWO-STAGE, TRANSFORMER-COUPLED, POWER AMPLIFIER FOR USE WITH 5-WATT TUBES

Cost of parts: Not more than $25.00 (*Note:* The costs of tubes and batteries are considered as "extras" and are not included in the costs given in these descriptions).
Usage: With loudspeaker.
Signal strength: Excellent, when added to a two-tube receiver.
Quality of reproduction: Good, if good transformers are used.
Construction: Not complicated.*
Outstanding features: No rheostats need be used with these tubes (Western Electric 216-a) on 6 volts. The plate circuit of the last tube includes a step-down transformer across the secondary of which is connected the loudspeaker.

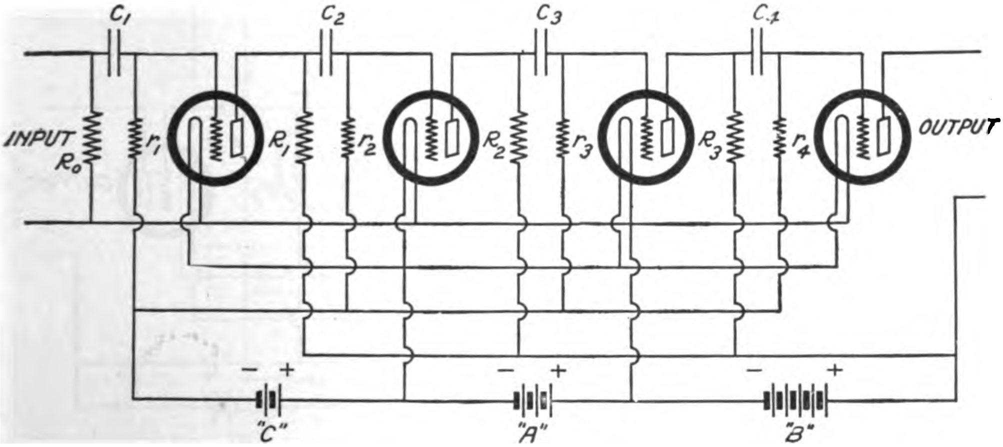
(See Popular Radio, January, 1924, page 69, for constructional details.)



ONE STAGE OF PUSH-AND-PULL POWER AMPLIFICATION

Cost of parts: Not more than $22.00.
Usage: With loudspeaker.
Signal strength: Very good when used with a single-stage of transformer-coupled amplification.
Quality of reproduction: Very good, if good transformers are used.
Construction: Just an ordinary acquaintance with tools and some ability in wiring up a circuit are necessary.*
Outstanding feature: This form of amplification takes advantage of both sides of the amplified alternating current that makes up audible voice signals.

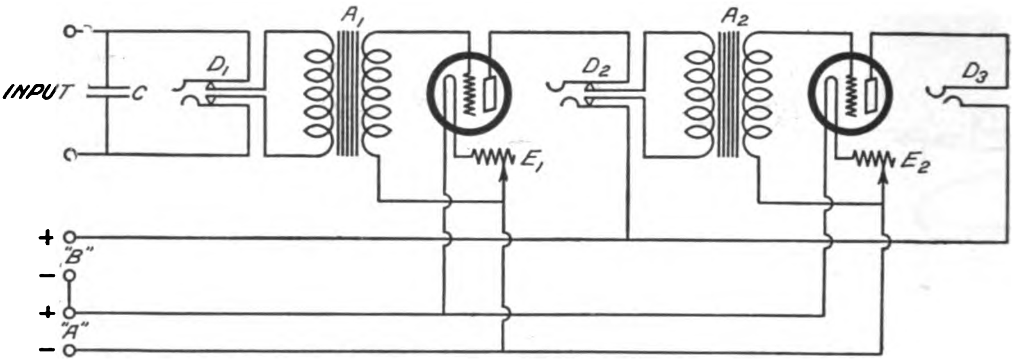
**(See* Popular Radio, *February, 1924, page 165, for constructional details.)*



RESISTANCE AND CONDENSER-COUPLED AMPLIFIER

Cost of parts: Not more than $20.00.
Usage: With phones or with loudspeaker.
Signal strength: Good.
Quality of reproduction: Excellent.
Construction: Fairly simple.*
Outstanding features: Truthfulness of reproduction and simplicity and low cost.

**(See* Popular Radio, *January, 1924, page 71, for constructional details.)*



TWO STAGES OF TRANSFORMER-COUPLED AMPLIFICATION

Cost of parts: Not more than $19.00.

Usage: With headphones or with loudspeaker.

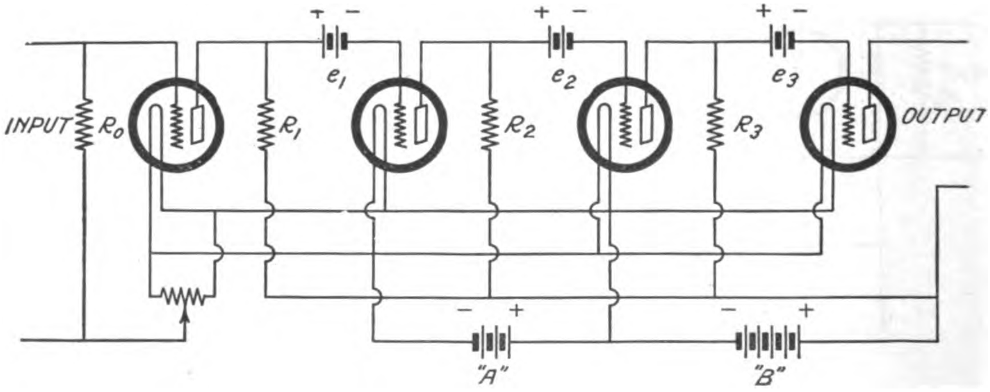
Signal strength: Good.

Quality of reproduction: Good, if good transformers are used.

Construction: There is nothing really difficult in putting together and wiring up such an amplifier.*

Outstanding feature: A simple circuit for getting consistent loudspeaker reception with a small number of tubes.

(See POPULAR RADIO, October, 1923, page 289, for constructional details.)



APERIODIC RESISTANCE-COUPLED AMPLIFIER

Cost of parts: Not more than $15.00.

Usage: With headphones or with loudspeaker.

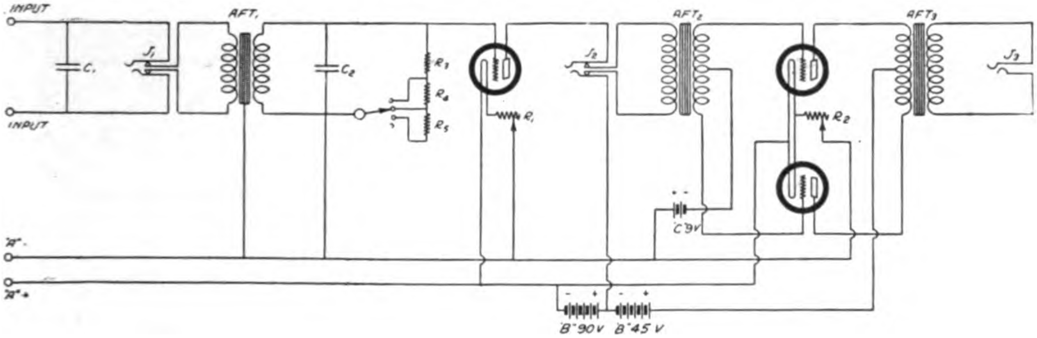
Signal strength: Good.

Quality of reproduction: Excellent.

Construction: Simple.*

Outstanding features: Perfect reproduction, if properly adjusted. Simplicity of construction. Low cost.

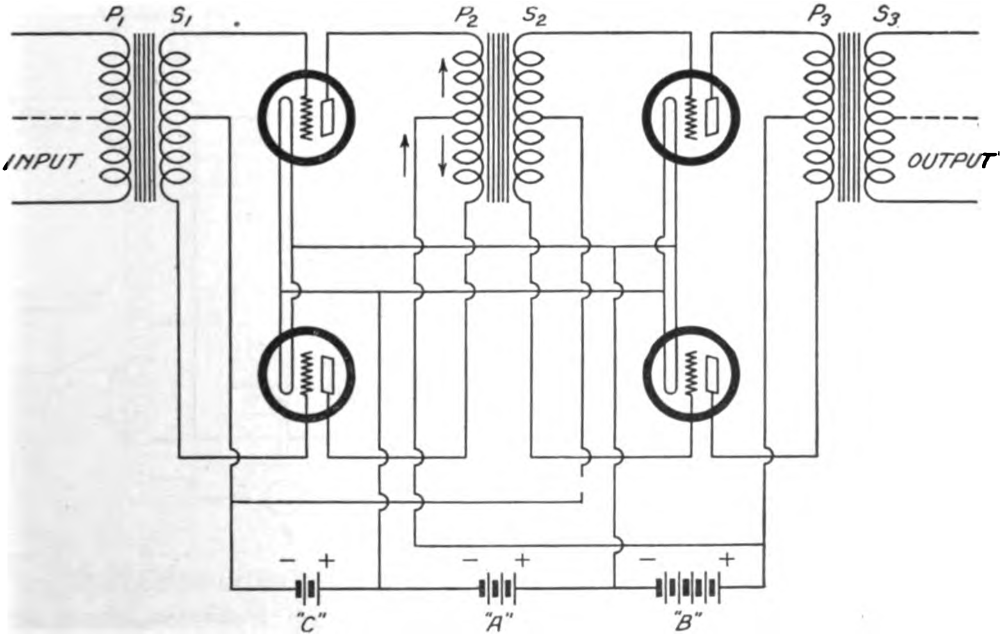
(See POPULAR RADIO, January, 1924, page 74, for constructional details.)



ONE STAGE OF TRANSFORMER-COUPLED, AND ONE STAGE OF PUSH-AND-PULL AMPLIFICATION

Cost of parts: Not more than $30.00.
Usage: With headphones or with loudspeaker.
Signal strength: Excellent.
Quality of reproduction: Very good, if good transformers are used.
Construction: Not very difficult to make.*
Outstanding feature: Large volume and good reproduction through a loudspeaker.

**(See* POPULAR RADIO, *February, 1924, pages 198-199, for constructional details.)*

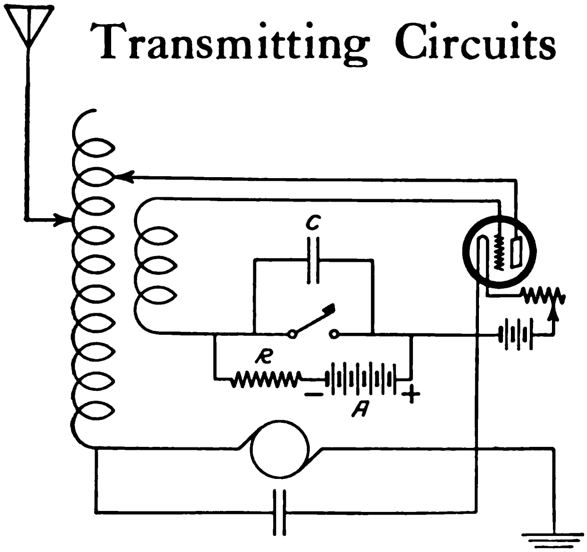


TWO STAGES OF PUSH-AND-PULL AMPLIFICATION

Cost of parts: Not more than $30.00.
Usage: With loudspeaker.
Signal strength: Excellent, when used as a power amplifier.
Quality of reproduction: Very good—if the transformers are good.
Construction: Rather complicated.*
Outstanding feature: Excellent for use as a power amplifier where great volume and good clarity is required.

**(See* POPULAR RADIO, *January, 1924, page 70, for constructional details.)*

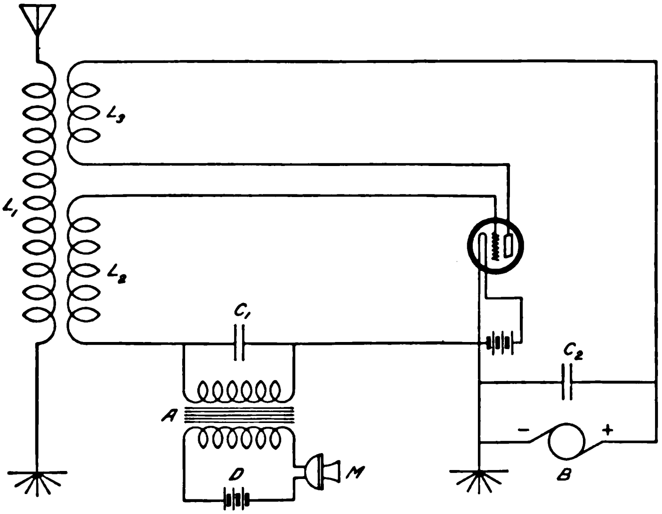
Transmitting Circuits



GRID-TICKLER CIRCUIT FOR PURE CW TELEPHONY

Cost of parts: Not more than $125.00.
Emitted wave: Extremely sharp.
Operation: Not difficult.
Construction: Nothing especially complicated in the arrangement of this set, but the builder should have had some experience in putting together receiving sets, wiring, soldering and the like before he attempts to make a transmitter.*
Approximate range: 1,000 miles.
Outstanding features: A sharp wave, and a pure "whistle" note for telephony.

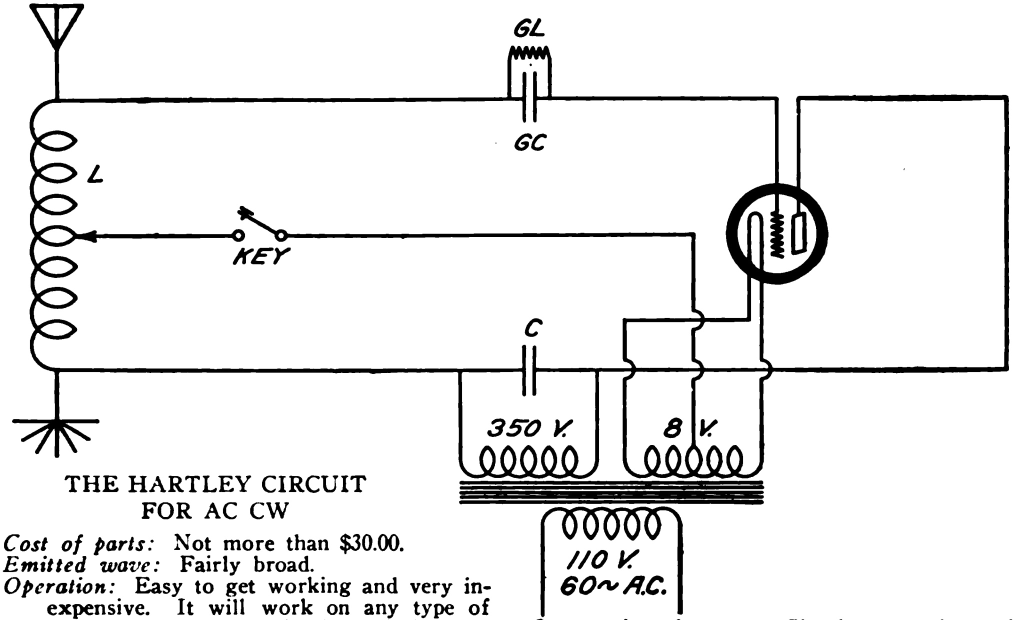
**(See* Popular Radio, *September, 1922, page 39, for constructional details.)*



THE MEISSNER CIRCUIT FOR TELEPHONY, WITH GRID MODULATION

Cost of parts: Not more than $120.00.
Emitted wave: Fairly sharp.
Operation: It is quite difficult to get a large percentage of modulation and still keep the transmitted speech clear.
Construction: The most important parts in this circuit are the coils; they should be wound on high-grade composition tubing with no shellac on the windings. A regular modulation transformer should be used at A.*
Approximate range: 50 to 100 miles (on telephony.)
Outstanding features: This is a good single-tube telephone outfit for the amateur. It will give him a lot of information and allow him to try a lot of experimenting to get better modulation.

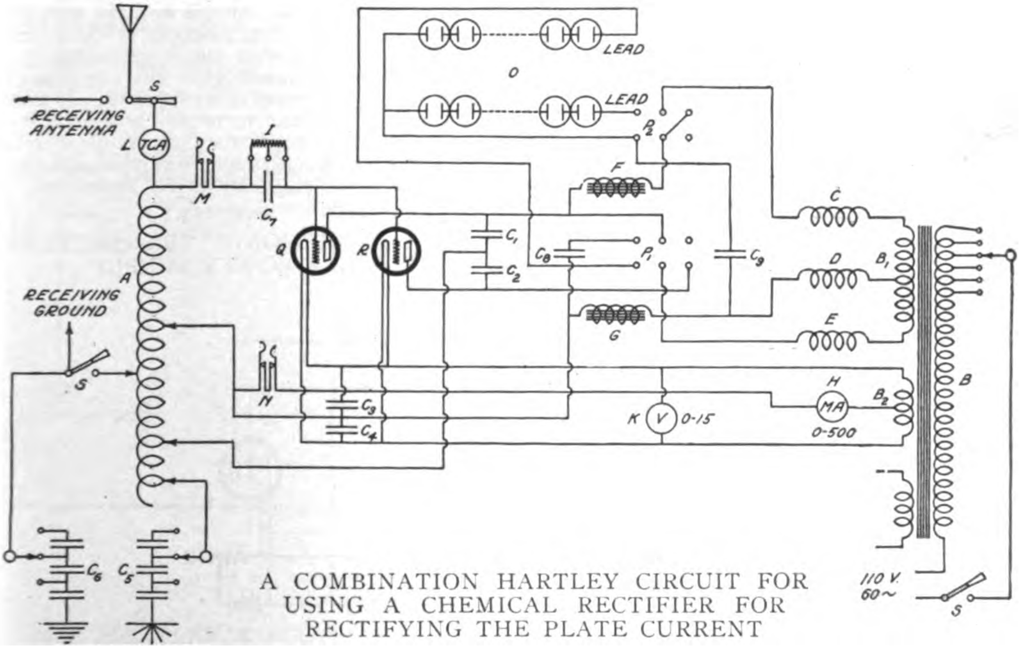
(See* Popular Radio, *July, 1923, page 42, for constructional details.)



THE HARTLEY CIRCUIT
FOR AC CW

Cost of parts: Not more than $30.00.
Emitted wave: Fairly broad.
Operation: Easy to get working and very inexpensive. It will work on any type of antenna. A counterpoise is advisable.
Construction: Simplicity itself.*
Approximate range: 500 miles.
Outstanding features: Simple to make and easy to get into operation. It is also most economical to set up.

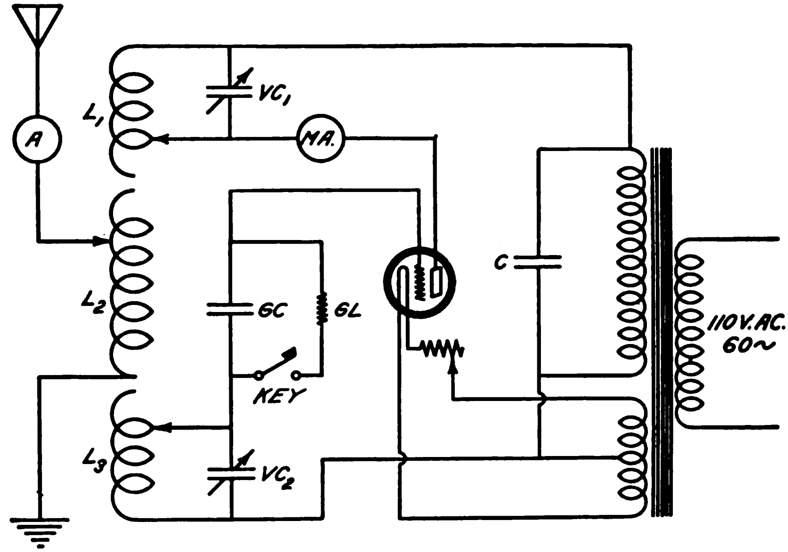
*(*See* Popular Radio, *December, 1923, page 513, for constructional details.*)



A COMBINATION HARTLEY CIRCUIT FOR USING A CHEMICAL RECTIFIER FOR RECTIFYING THE PLATE CURRENT

Cost of parts: Not more than $125.00 (for use with 50-watt tubes).
Emitted wave: Broad (with self-rectified AC). Somewhat sharper (with chemically-rectified AC. It depends upon how good the filter is).
Operation: Complicated.
Construction: None but the experienced amateur had better try to build this set alone.*
Approximate range: 2,500 to 3,000 miles (on telephony).
Outstanding feature: A powerful set which can be used without batteries for CW telegraphy.

*(*See* Popular Radio, *April, 1923, page 298, for constructional details.*)



MODIFIED MEISSNER CIRCUIT WITH AC POWER SUPPLY

Cost of parts: Not more than $40.00 (*Note:* The costs of tubes and batteries are considered "extras" and are not included in the costs given in these descriptions).

Emitted wave: Fairly broad. Using straight AC on the plate of the oscillator tube causes a 30-cycle note to be transmitted (as the modulator frequency) which spreads out the frequency to a band instead of a single pure wave. This will cause interference in nearby receivers which do not tune sharply.

Operation: Easy to get working and inexpensive to keep up. The first cost is the last cost except for tube replacements. It will work on any type of antenna.

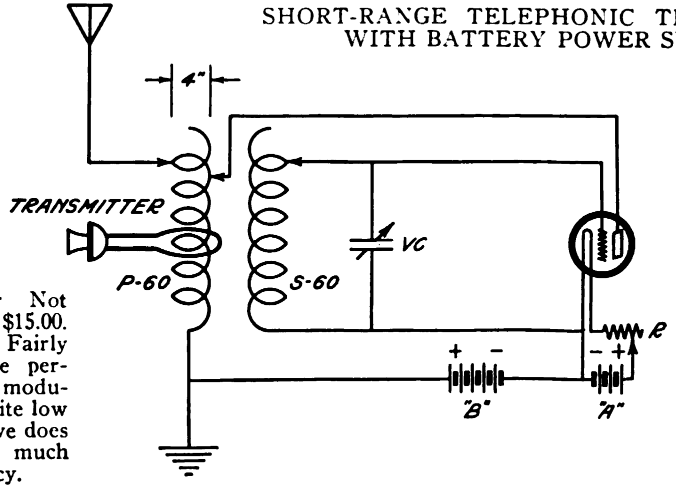
Construction: Nothing difficult about making this set, probably as simple as a single-tube receiving set.*

Approximate transmitting range: 500 miles.

Outstanding features: Simple to make and get into operation. Set functions without any moving parts to wear out, is applicable to a large band of wavelengths with any type of antenna, and requires no batteries. It may cause interference to nearby broadcast listeners, however, if they use single-circuit tuners or other simple sets that are deficient in tuning qualities for reception.

*(See POPULAR RADIO, *April, 1923, page 312, for constructional details.)*

SHORT-RANGE TELEPHONIC TRANSMITTER WITH BATTERY POWER SUPPLY



Cost of parts: Not more than $15.00.

Emitted wave: Fairly sharp. The percentage of modulation is quite low and the wave does not spread much in frequency.

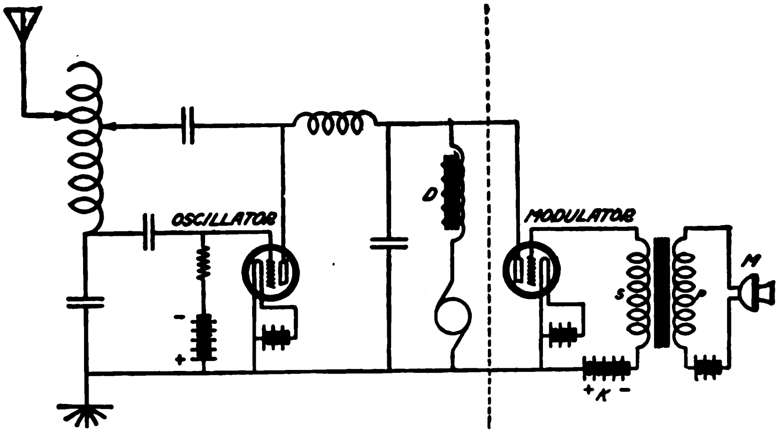
Operation: Just as simple as a single-circuit receiving set. The UV-201-a tube may be used with about 100 volts of "B" battery for the plate supply.

Construction: Simplicity itself.*

Approximate transmitting range: 5 miles.

Outstanding features: Simple to make and operate.

*(See POPULAR RADIO, *April, 1923, page 309, for constructional details.)*



THE COLPITTS CIRCUIT WITH HEISING MODULATION

Cost of parts: Not more than $130.00.

Emitted wave: Fairly sharp. The modulation is (if the set is properly adjusted) of a very high order and also of a high percentage. This may cause the wave to be broadened out so that the set may interfere locally.

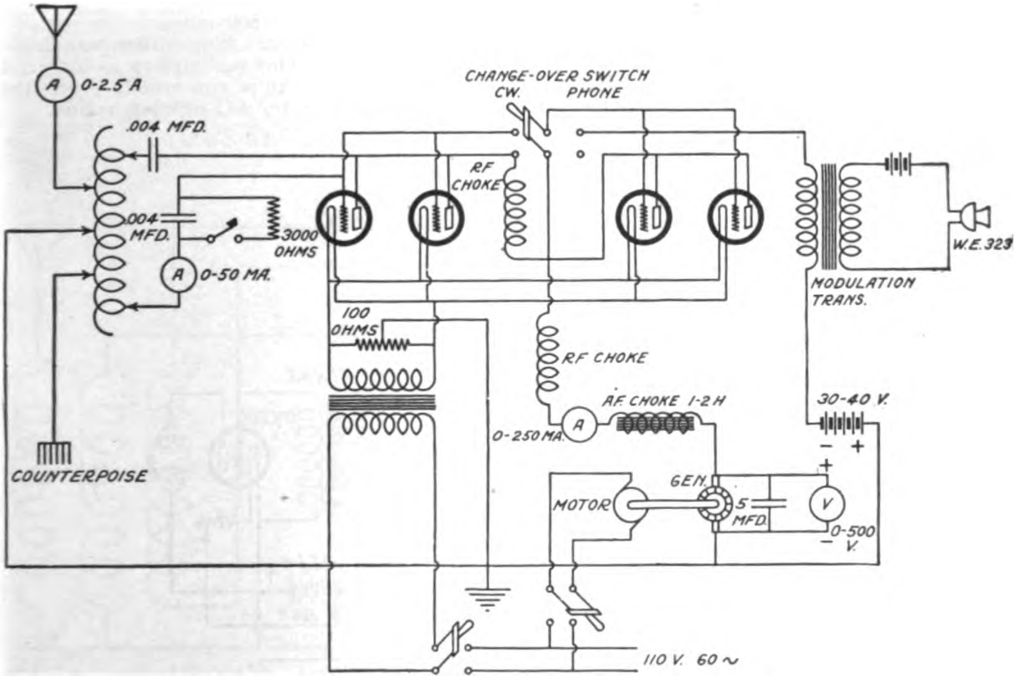
Operation: Simple and efficient.

Construction: Rather complicated.*

Approximate range: 500 to 1,000 miles (on telephony).

Outstanding features: The best modulating system and the one most used for broadcasting.

**(See* Popular Radio, *July, 1923, page 46, for constructional details.)*



THE HARTLEY CIRCUIT USING HEISING MODULATION FOR TELEPHONY

Cost of parts: Not more than $175.00.

Emitted wave: Extremely sharp for CW and good on telephony.

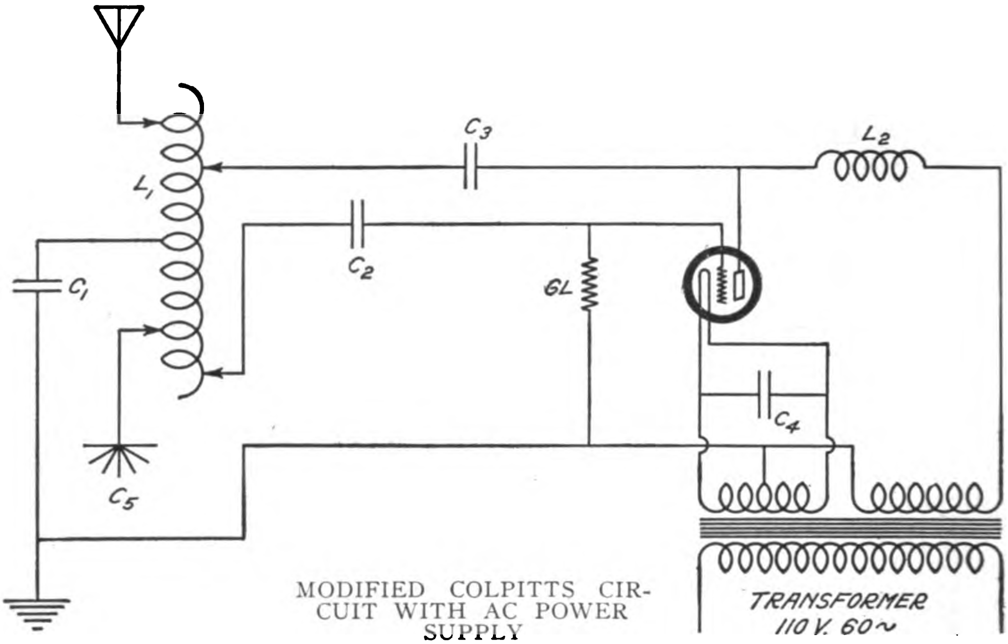
Operation: Complicated. A thorough understanding of the principles of modulation is necessary to get the set operating efficiently on telephony.

Construction: Difficult.*

Approximate range: 2,500 miles (on CW), and 1,000 miles (on telephony).

Outstanding features: This circuit is noted for its efficiency and perfection of modulation. This type of modulation is used at most of the broadcasting stations.

**(See* Popular Radio, *December, 1922, page 256, for constructional details.)*

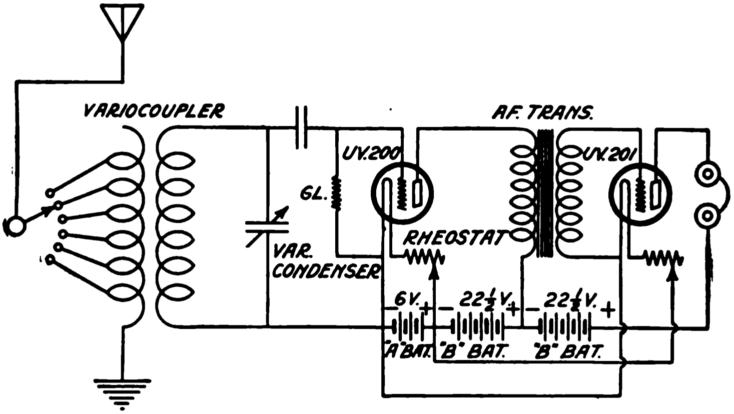


MODIFIED COLPITTS CIRCUIT WITH AC POWER SUPPLY

Cost of parts: Not more than $35.00.
Emitted wave: Fairly broad. (This is due to the AC power supply and not to the type of circuit used.)
Operation: Simple to get into successful operation (if a counterpoise is used).
Construction: Not complicated.*
Approximate range: 500 miles.
Outstanding features: A persistent oscillator and efficient. This set employs no batteries of any kind. It is run wholly from the 110-volt, 60-cycle, AC lighting mains.

*(See Popular Radio, *September, 1923, page 249, for constructional details.)*

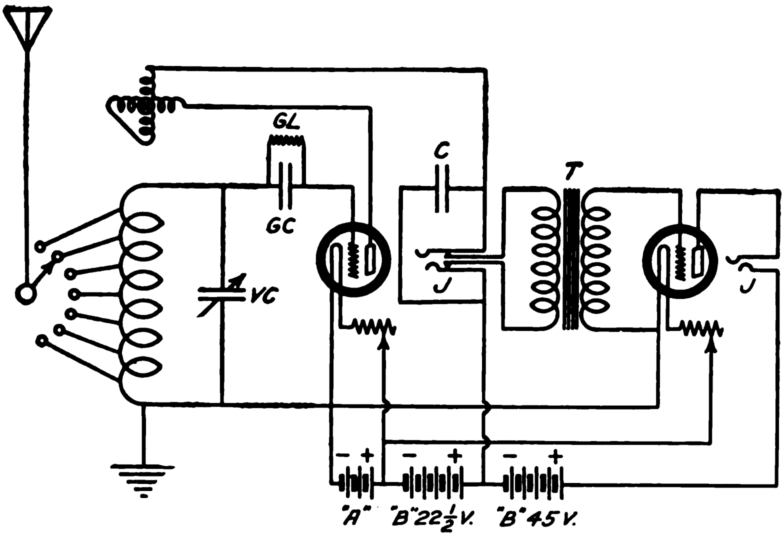
Two-tube Circuits



INDUCTIVELY-COUPLED, VACUUM-TUBE RECEIVER WITH ONE STAGE OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $28.00.
Selectivity: Fairly good.
Operation: Simple.
Construction: Easy to make.*
Approximate range: About 100 miles.
Outstanding features: The added stage of amplification increases the operating range considerably and makes the local programs more enjoyable for use with a number of headphones.

*(See Popular Radio, *October, 1922, page 147, for constructional details.)*



THE CONDUCTIVELY-COUPLED, TUNED-PLATE REGENERATIVE CIRCUIT WITH ONE STAGE OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $30.00.

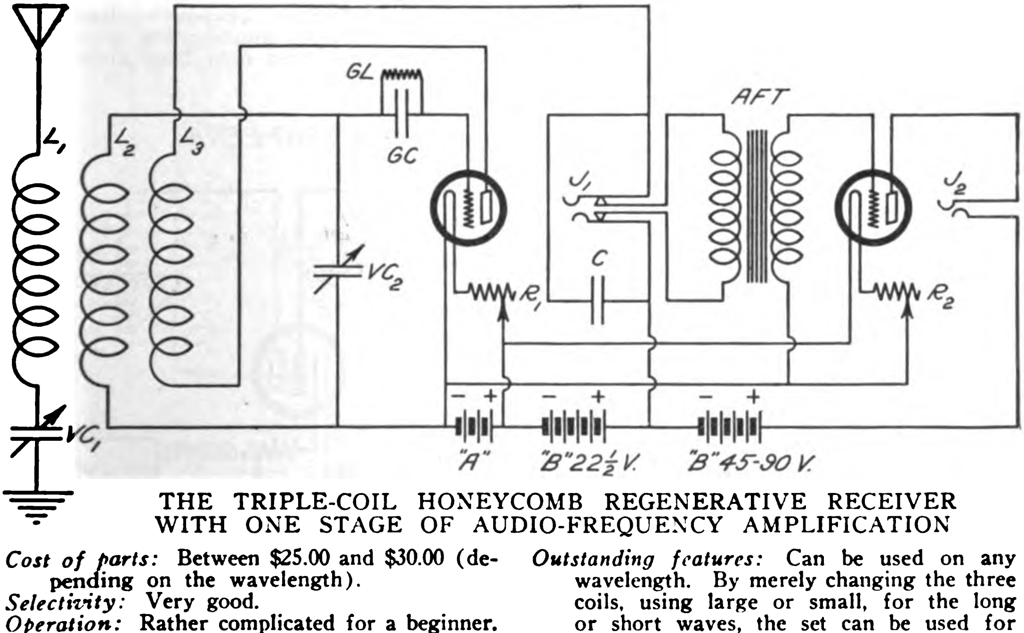
Selectivity: Fair.

Operation: Not very complicated. The antenna is tuned by means of a tapped switch, the secondary by means of a variable condenser and the regeneration is controlled by the variometer.

Ease of construction: Just an ordinary acquaintance with tools and some ability in wiring up the circuit are necessary.

Approximate range: 800 to 1,000 miles.

Outstanding features: Easy to operate and will bring in distance with good volume on a pair of telephones. Good for amateur CW reception.



THE TRIPLE-COIL HONEYCOMB REGENERATIVE RECEIVER WITH ONE STAGE OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Between $25.00 and $30.00 (depending on the wavelength).

Selectivity: Very good.

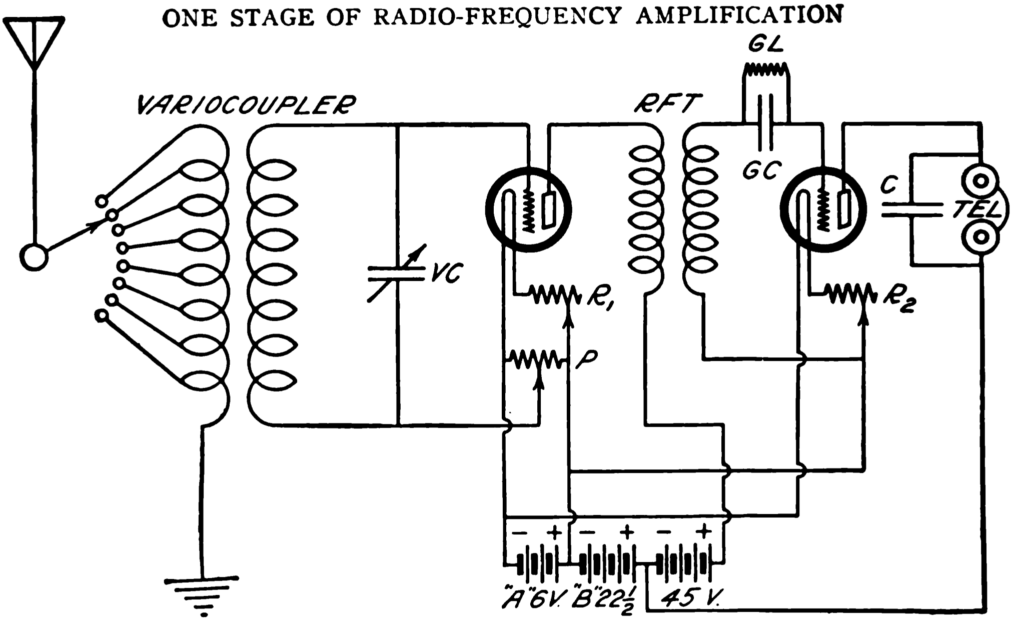
Operation: Rather complicated for a beginner.

Ease of construction: Fairly simple.

Approximate range: 800 miles.

Outstanding features: Can be used on any wavelength. By merely changing the three coils, using large or small, for the long or short waves, the set can be used for commercial reception, broadcast reception or amateur reception.

ONE STAGE OF RADIO-FREQUENCY AMPLIFICATION



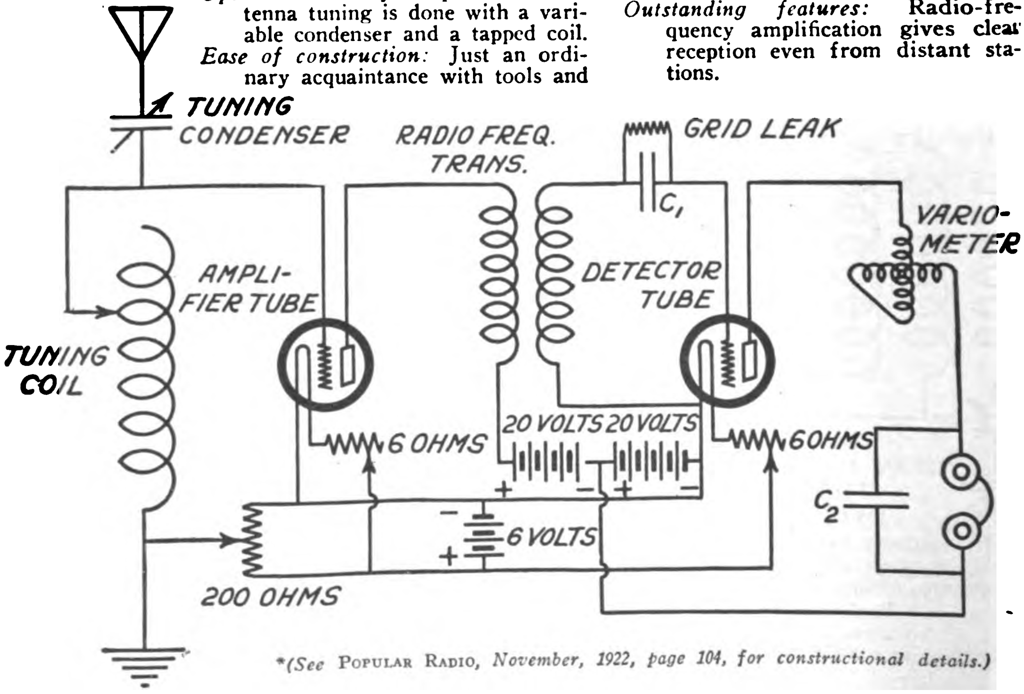
Cost of parts: Not more than $28.00.
Selectivity: Good.
Operation: Not difficult.
Construction: Nothing especially complicated.*

Approximate range: 500 miles.
Outstanding feature: A good circuit for the man who has a simple vacuum-tube circuit and wishes to make it more sensitive.

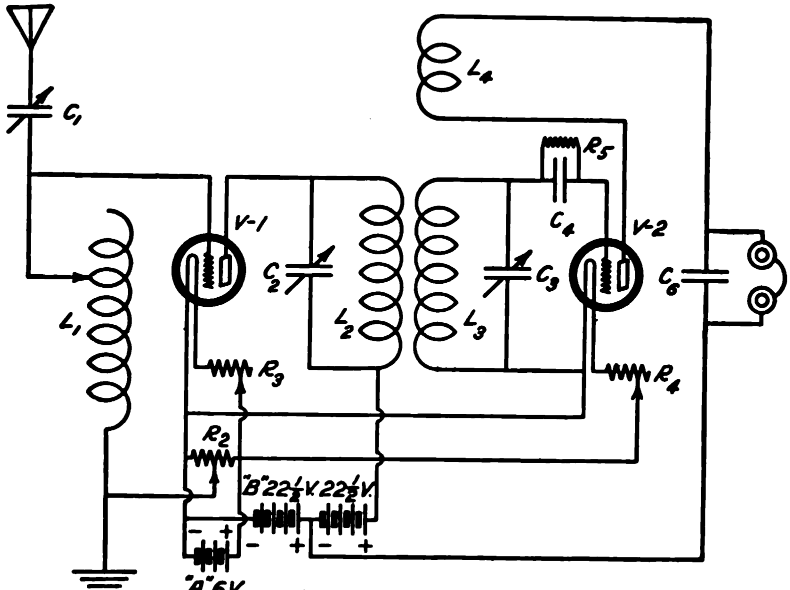
*(See POPULAR RADIO, *June, 1923, page 471, for constructional details.)*

A REGENERATIVE DETECTOR CIRCUIT

Cost of parts: Not more than $40.00.
Selectivity: Good.
Operation: Fairly simple. The antenna tuning is done with a variable condenser and a tapped coil.
Ease of construction: Just an ordinary acquaintance with tools and some ability in wiring up a circuit are necessary.*
Approximate range: 800 to 1,000 miles.
Outstanding features: Radio-frequency amplification gives clear reception even from distant stations.

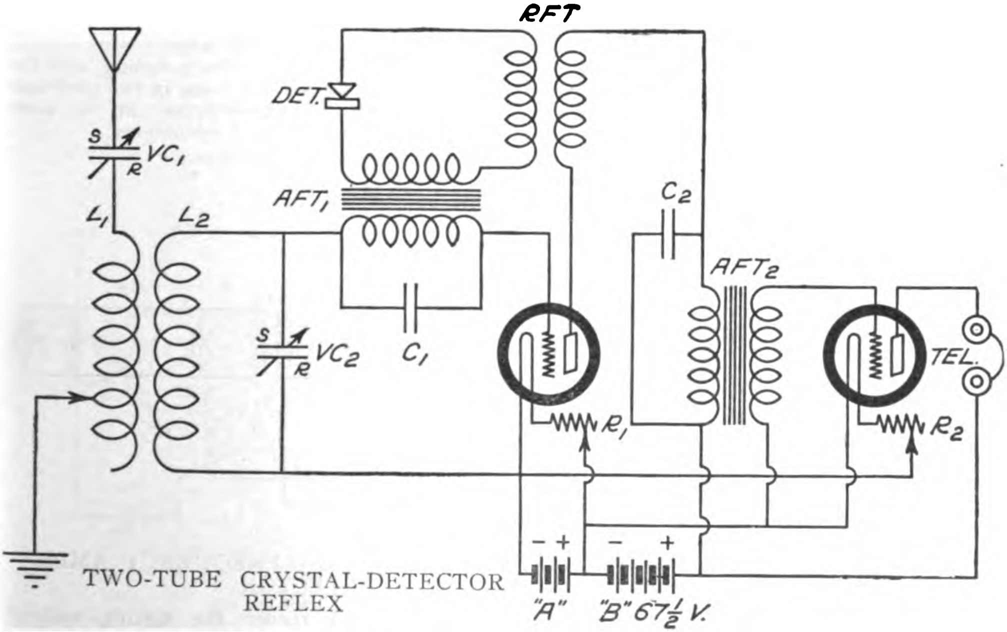


*(See POPULAR RADIO, *November, 1922, page 104, for constructional details.)*



TUNED RADIO-FREQUENCY CIRCUIT

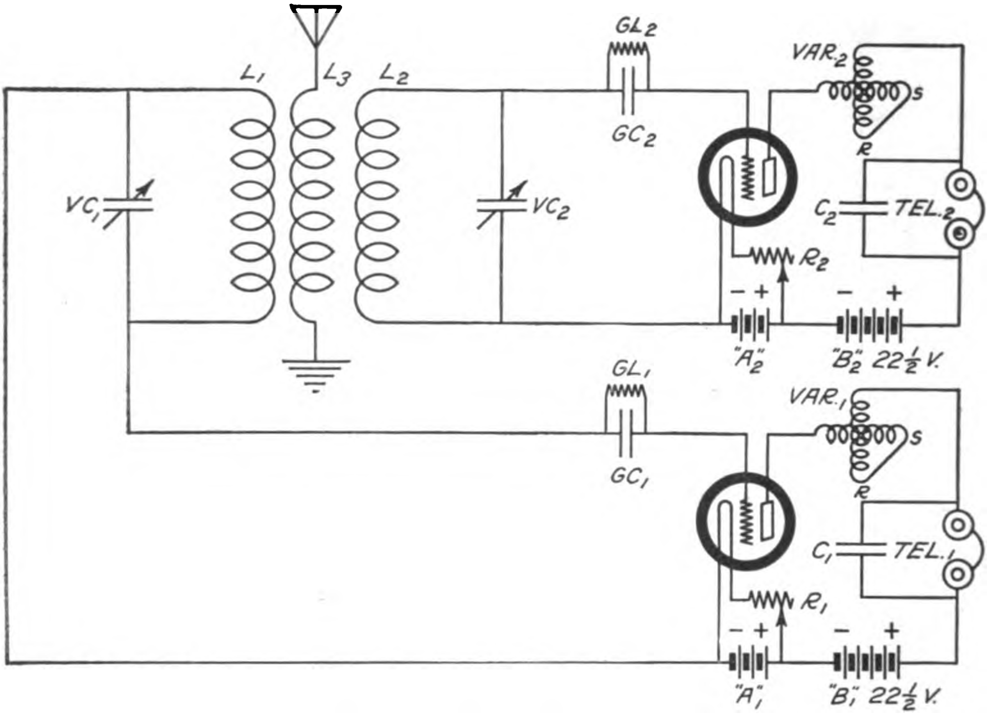
Cost of parts: Not more than $28.00.
Selectivity: Good.
Operation: Rather complicated for a beginner.
Ease of construction: Easy.
Approximate range: 500 miles.
Outstanding features: May be used with short indoor antenna. It may be made from a single-circuit, honeycomb set to stop reradiation, and may be used to give the builder a good idea of radio-frequency amplification before he tries out the more complicated circuits.



TWO-TUBE CRYSTAL-DETECTOR REFLEX

Cost of parts: Not more than $45.00.
Selectivity: Very good.
Operation: Fairly simple.
Construction: Not easy to make. Care must be used in mounting the transformers in the proper position with respect to each other.*
Approximate range: 1,000 miles.
Outstanding features: Loudspeaker operation is possible with only two tubes. The circuit has the advantage, also, of being workable with a short antenna.

(See Popular Radio, March, 1924, page 293, for constructional details.)



A DUPLEX REGENERATIVE RECEIVER

Cost of parts: Not more than $55.00.

Selectivity: Very good.

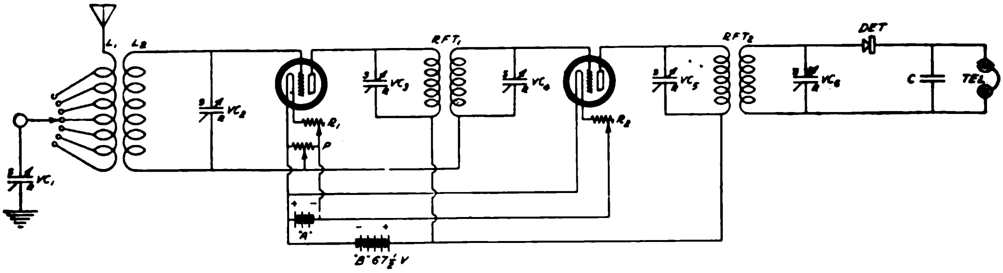
Operation: A few weeks' practice will suffice to enable efficient tuning of both parts of the set.

Construction: Just an ordinary acquaintance with tools and some ability in wiring up the circuit are necessary.*

Approximate range: 500 miles.

Outstanding features: Sharp tuning, and the fact that the set will bring in two programs (on different wavelengths) at the same time on two pairs of telephones.

**(See* Popular Radio, *January, 1924, page 96, for constructional details.)*



CIRCUIT EMPLOYING TWO STAGES OF TUNED-RADIO-FREQUENCY AMPLIFICATION, WITH A CRYSTAL DETECTOR

Cost of parts: Not more than $56.00.

Selectivity: Excellent.

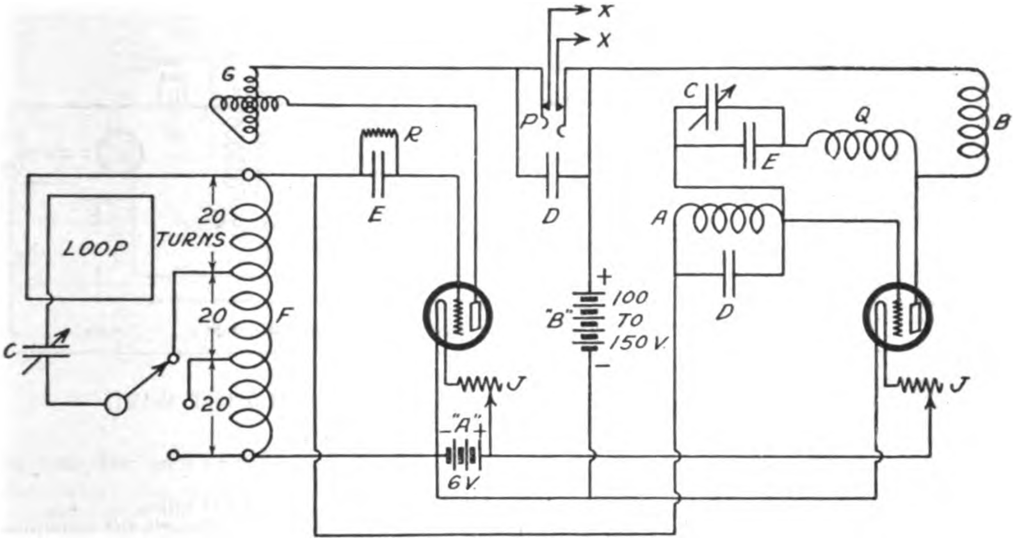
Operation: Rather critical in operation.

Construction: Not very hard to make. Be sure that the best parts are obtained and the results will exceed expectations. Poor parts will render the circuit useless.*

Approximate range: 1,500 miles.

Outstanding features: A set for the man who wants distance, but who is willing to depend on the headphones instead of trying to use a loudspeaker.

**(See* Popular Radio, *April, 1924, pages 400-1, for constructional details.)*



TWO-TUBE SUPER-REGENERATIVE CIRCUIT

Cost of parts: Not more than $45.00

Selectivity: Good.

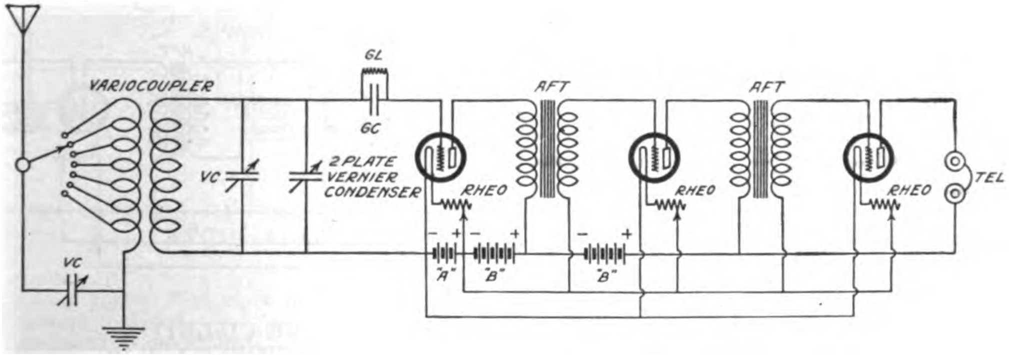
Operation: Difficult. It is a real engineering feat to get the oscillator circuit to function with the correct frequency and amplitude to cause the proper "super" action and at the same time filter out the high-pitched whistle in the detector circuit.

Ease of construction: Difficult. Every part of the circuit must be just right before the set will function as it should.

Approximate range: Variable; from local reception on the higher broadcasting wavelengths up to 1,000 miles on lower wavelengths (with a loop).

Outstanding features: The best method for unlimited amplification at the extremely short wavelengths. Especially suitable for local reception with great volume for a minimum number of tubes.

Three-tube Circuits



A SIMPLE AUDION CIRCUIT WITH TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $40.00.

Selectivity: Fairly good.

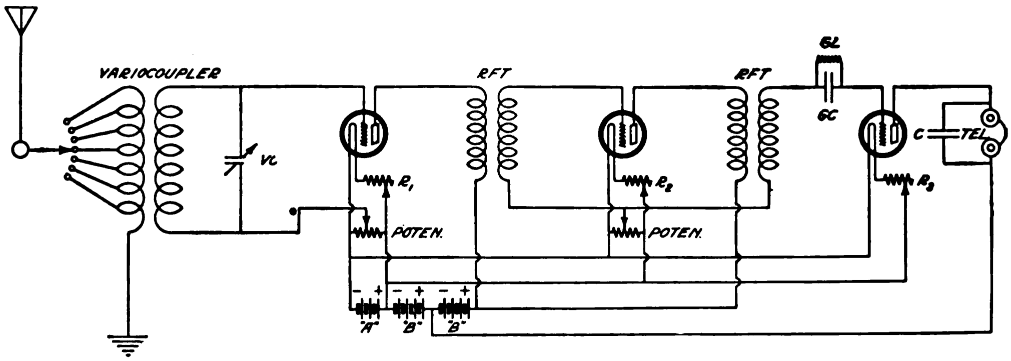
Operation: Easy to operate.

Construction: Simple.*

Approximate range: 300 miles.

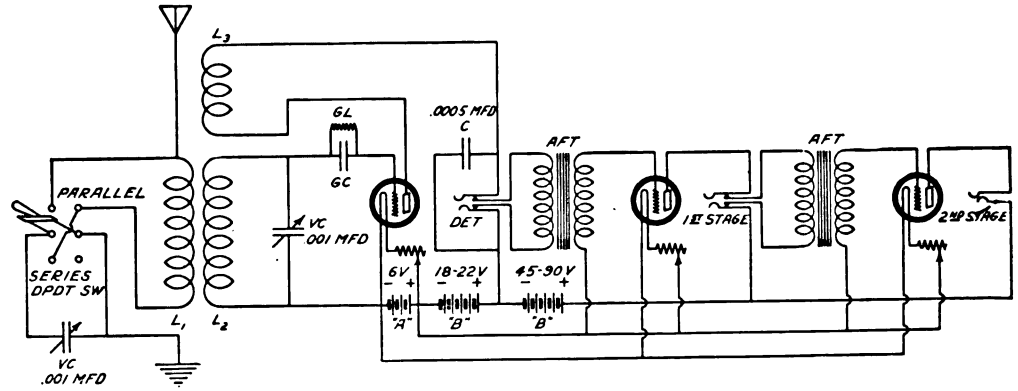
Outstanding feature: The set will bring in any signals, with great clarity, as long as they are strong enough to operate the detector.

*(*See* Popular Radio, *March, 1923, pages 232-233, for constructional details.)*



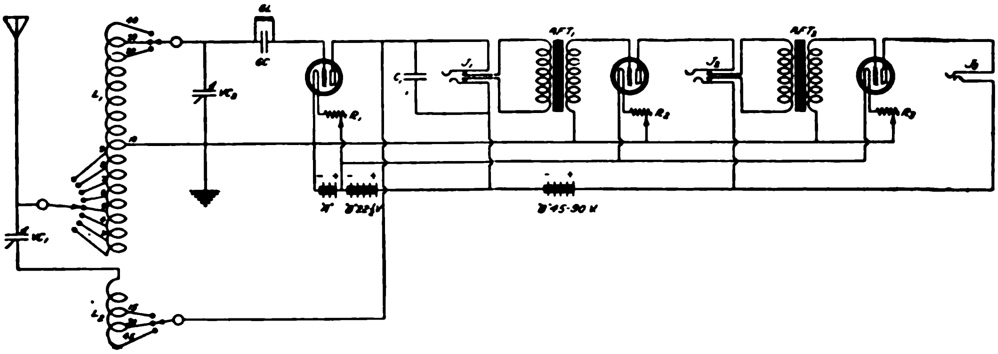
TRANSFORMER-COUPLED RADIO-FREQUENCY CIRCUIT WITH VACUUM-TUBE DETECTOR

Cost of parts: Not more than $35.00.
Selectivity: Good.
Operation: Simple. Two controls for wavelength, one for coupling and one for regeneration (the potentiometer).
Ease of construction: Not easy for the experimenter to get working right but a little patience and experimenting will soon get results.
Approximate range: 1,000 miles.
Outstanding feature: Although the amplification with this type is not as great (per stage), as with tuned-radio-frequency amplification, the tuning control is simplified.



TRIPLE-COIL, HONEYCOMB REGENERATIVE CIRCUIT WITH TWO STAGES OF AMPLIFICATION

Cost of parts: Not more than $35.00.
Selectivity: Good.
Operation: Rather complicated.
Ease of construction: Not hard to make.
Approximate range: 1,000 miles on the low broadcasting and amateur wavelengths and 3,000 miles on the extreme high wavelengths.
Outstanding features: It may be made to cover all wavelengths by interchanging coils. The coils may be plugged into sockets at will, thus making the set into a high or low wave receptor which is regenerative.



THE REINARTZ CIRCUIT, WITH TWO STAGES OF AUDIO AMPLIFICATION

Cost of parts: Not more than $35.00.

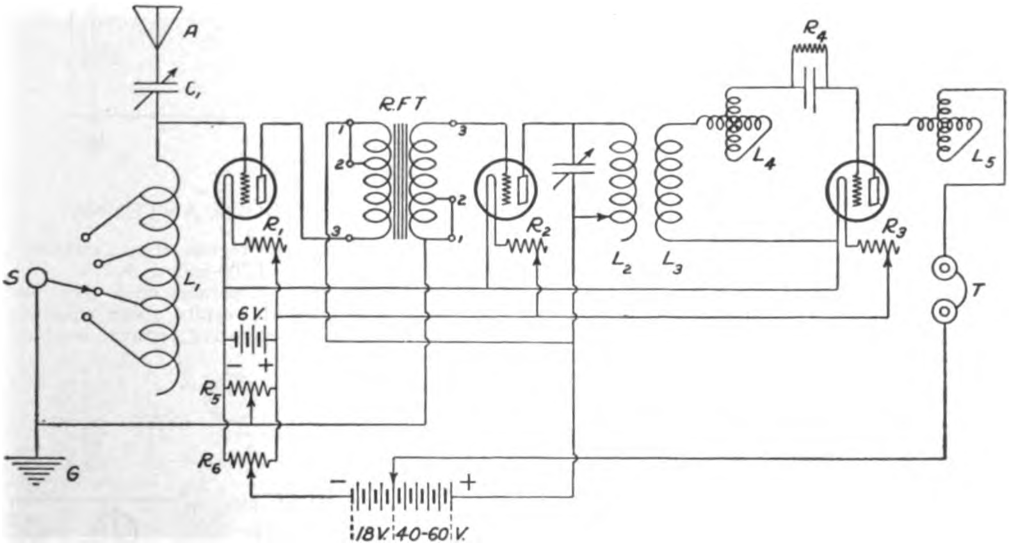
Selectivity: Excellent on amateur wavelengths, very good on broadcasting wavelengths.

Operation: Easy when mastered; about a month's practice should suffice to become well enough acquainted with the peculiarities of the tuning.

Ease of construction: Simple.

Approximate range: 1,500 miles.

Outstanding features: It is noted for its DX amateur reception and its low cost.



TWO STAGES OF TRANSFORMER-COUPLED, RADIO-FREQUENCY AMPLIFICATION ADDED TO THE TWIN-VARIOMETER, VARIO-COUPLER, REGENERATIVE CIRCUIT

Cost of parts: Not more than $50.00.

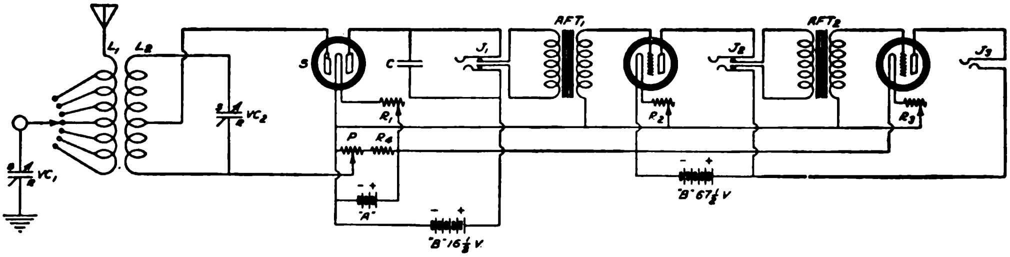
Selectivity: Good.

Operation: Complicated. The antenna must be tuned with the tapped switch and the variable condenser. There are two potentiometer adjustments, one for the stabilizer for the radio-frequency tubes, and one for adjusting the plate potential of the detector tube. Then the output circuit of the second radio-frequency tube must be tuned with the variable condenser, and the regular tuning of the variometers in the grid and plate circuits of the detector must be done before the signal is tuned in properly.

Ease of construction: Fairly complicated.

Approximate range: 1,500 miles.

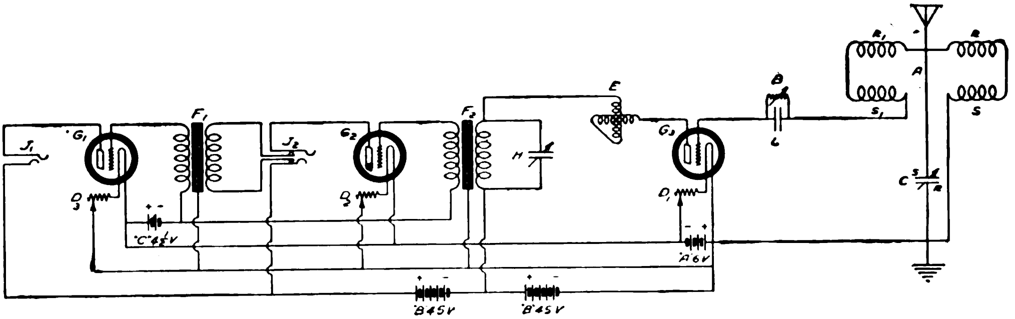
Outstanding features: Is reliable for distance reception without the audio-frequency amplification that is usually used with this detector circuit. The radio-frequency amplification brings in the distance with much greater strength without appreciably increasing the local signals.



DONLE DETECTOR CIRCUIT WITH TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $38.00.
Selectivity: Fair.
Operation: Very simple.
Construction: Not hard to put together.*
Approximate range: 1,000 miles.
Outstanding feature: This circuit uses the new type of sodion tube which is extremely sensitive but which cannot oscillate or radiate.

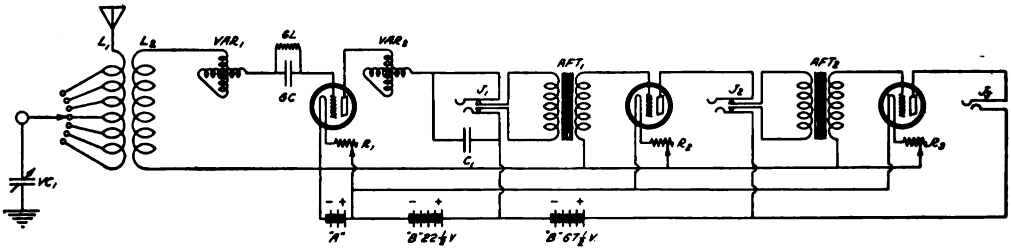
*(See Popular Radio, *March, 1924, pages 294-5, for constructional details.)*



THE TOBIAS CIRCUIT FOR RECEPTION WITH AN INDOOR ANTENNA

Cost of parts: Not more than $55.00.
Selectivity: Excellent, if used on a short antenna.
Operation: Not hard to tune, once the mode of adjustment has been thoroughly learned.
Construction: No more complicated than other types of regenerative circuits.*
Approximate range: 1,200 miles.
Outstanding feature: Operates on a short indoor antenna with results about equal to the ordinary regenerative receiver used on an outdoor one.

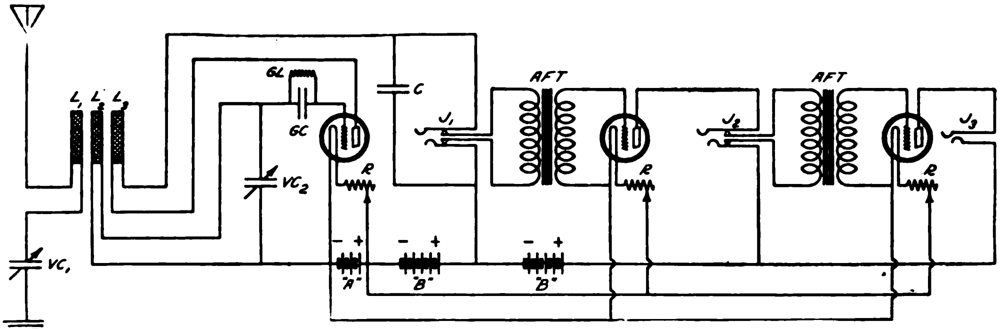
*(See Popular Radio, *June, 1924, page 567, for constructional details.)*



TWIN-VARIOMETER, VARIOCOUPLER REGENERATIVE CIRCUIT WITH TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $45.00.
Selectivity: Good
Operation: Difficult.
Ease of construction: Just an ordinary acquaintance with tools and some ability in wiring up the circuit is necessary.*
Approximate range: 1,200 miles.
Outstanding features: All the tuning is inductive and this makes for louder signals, at a slight loss of selectivity. Both tuning and regeneration are controlled by variometers.

*(See Popular Radio, *October, 1923, page 329, for constructional details.)*



TRIPLE-COIL HONEYCOMB REGENERATIVE RECEIVER WITH TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $45.00.

Selectivity: Good.

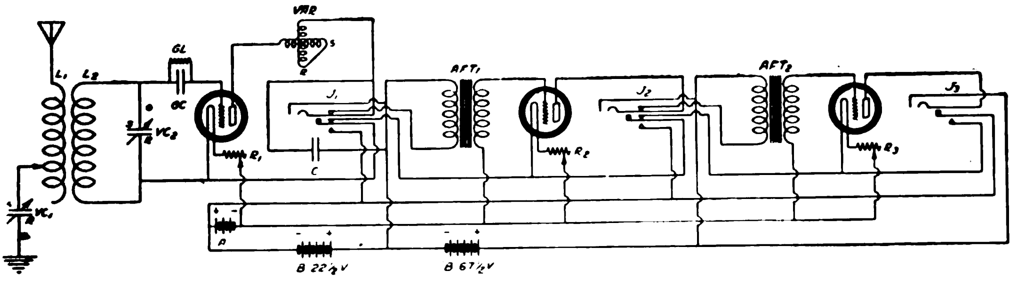
Operation: Rather difficult to tune.

Ease of construction: The building of such a set is more difficult than the single-circuit tuner but better results in tuning will be worth the extra trouble, and the amplifier will make the set suitable for loudspeaker reception.*

Approximate range: 1,200 miles.

Outstanding feature: The set can be used for reception on any wavelength range by merely changing the size of coils.

**(See* POPULAR RADIO, *April, 1923, page 308, for constructional details.)*



REGENERATIVE RECEIVER WITH TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION, EQUIPPED WITH AUTOMATIC FILAMENT-LIGHTING JACKS

Cost of parts: Not more than $45.00.

Selectivity: Excellent.

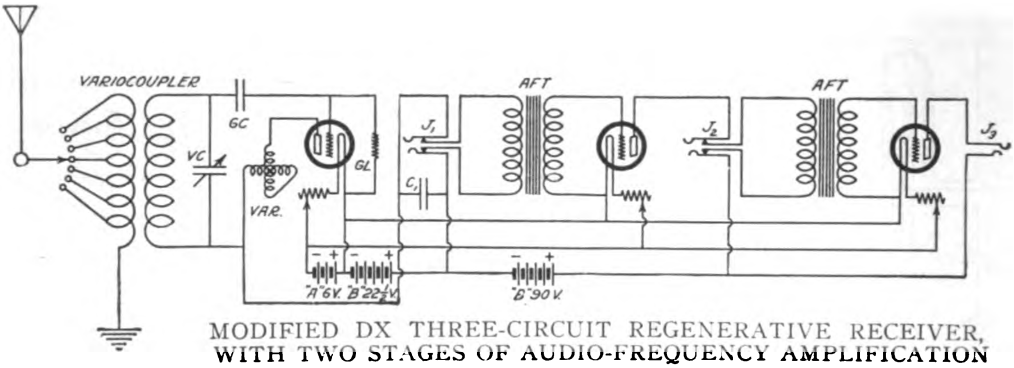
Operation: Simple. The primary and secondary condensers control tuning, with the variocoupler for coupling control and the plate variometer for effecting regeneration. By merely inserting the telephone plug into the stage desired the filaments used are automatically turned on and off.

Construction: Some care is necessary in laying out the circuit and in wiring up the filament circuit.*

Approximate range: 1,200 to 1,500 miles.

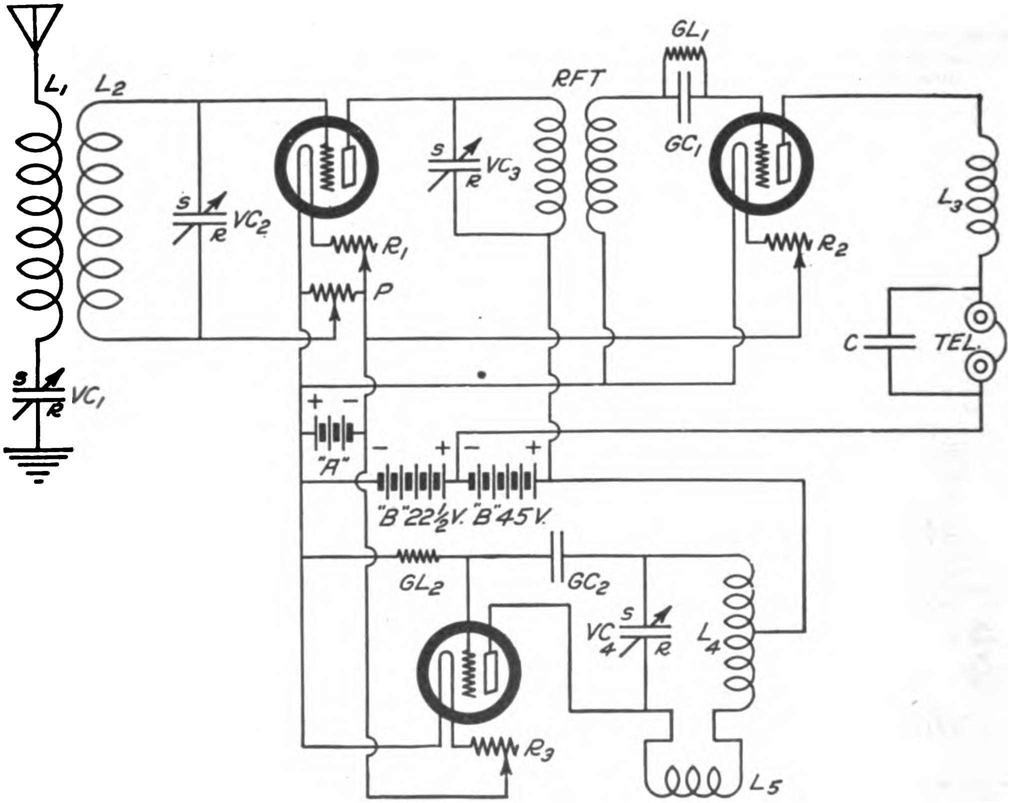
Outstanding features: Selectivity. Automatic filament control.

**(See* POPULAR RADIO, *July, 1924, pages 80-1, for constructional details.)*



MODIFIED DX THREE-CIRCUIT REGENERATIVE RECEIVER, WITH TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

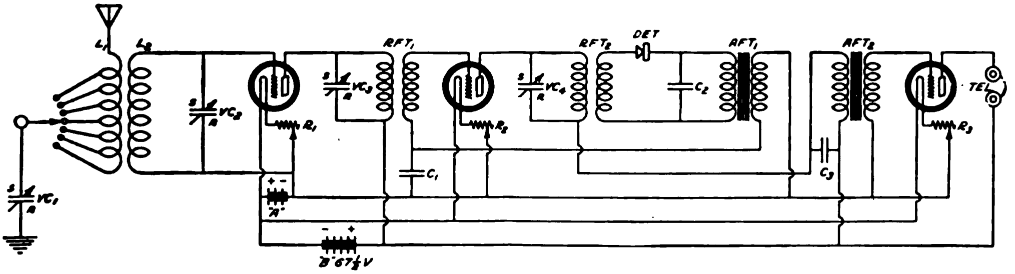
Cost of parts: Not more than $35.00
Selectivity: Excellent.
Operation: Fairly simple.
Ease of construction: Fairly easy to build.
Approximate range: 1,500 miles.
Outstanding features: Noted for DX amateur and broadcast reception and for its exceptionally sharp tuning.



ONE STAGE OF TUNED-RADIO-FREQUENCY, VACUUM-TUBE DETECTOR, WITH SEPARATE HETERODYNE FOR CW RECEPTION

Cost of parts: Not more than $50.00.
Selectivity: Excellent.
Operation: Difficult to tune.
Construction: Only the experienced radio experimenter should try to build this receiver.*
Approximate range: 1,500 to 2,000 miles for CW.
Outstanding feature: Excellent for reception of continuous-wave telegraphy.

*(*See* POPULAR RADIO, *July 1924, page 77, for constructional details.)*



TWO STAGES OF TUNED-RADIO-FREQUENCY AMPLIFICATION, CRYSTAL DETECTOR AND TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $60.00.

Selectivity: Very good. Tuning is accomplished entirely by means of variable condensers.

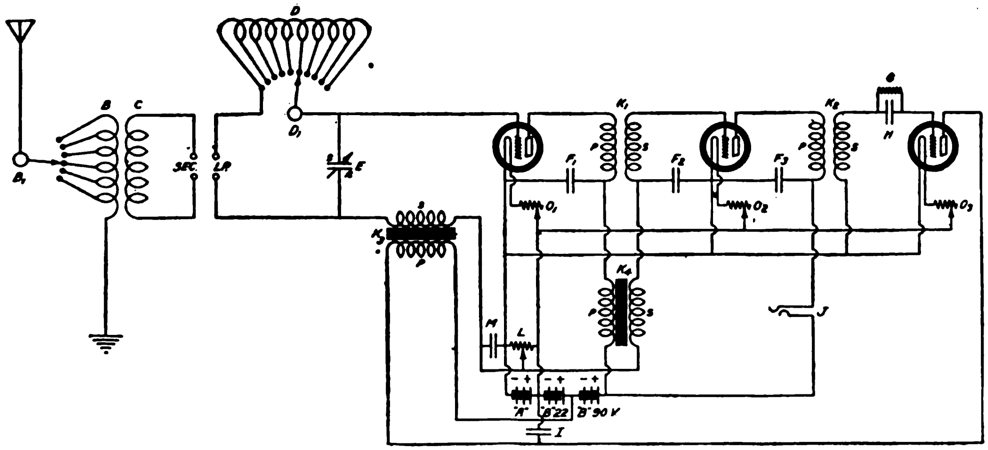
Operation: Rather complicated. The tuning should be done by logging the settings for the various wavelengths.

Construction: Not a simple set to make. Some experience in making sets should be had before attempting construction.*

Approximate range: 2,500 miles.

Outstanding features: Only three tubes are used. One stage of audio-frequency amplification is reflexed.

**(See* Popular Radio, *January, 1924, pages 80-1, for constructional details.)*



THE REMY REFLEX

Cost of parts: Not more than $70.00.

Selectivity: Very good.

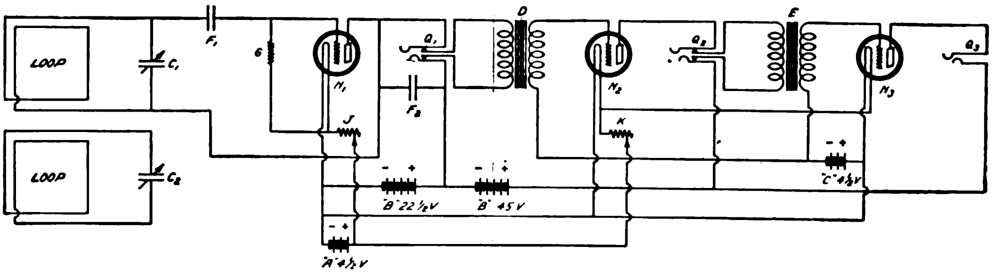
Operation: Simple.

Construction: Not very difficult to make. Refer to the article in the issue given below.*

Approximate range: See Remy's article.

Outstanding features: Simplicity of control and economical from a tube standpoint.

**(See* Popular Radio, *February, 1924, page 167, for constructional details.)*

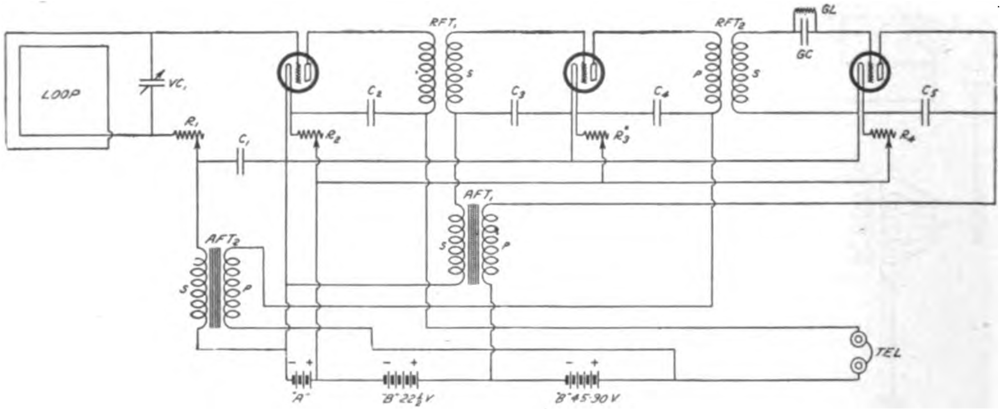


FOUR-CIRCUIT PORTABLE RECEIVER

Cost of parts: Not more than $50.00.
Selectivity: Excellent.
Operation: Simple.
Construction: Not difficult.*

Approximate range: Local.
Outstanding feature: All parts mounted in a cabinet, including loops, batteries and tubes.

**(See* Popular Radio, *February, 1924, page 152, for constructional details.)*



THE GRIMES REFLEX CIRCUIT

Cost of parts: Not more than $40.00.

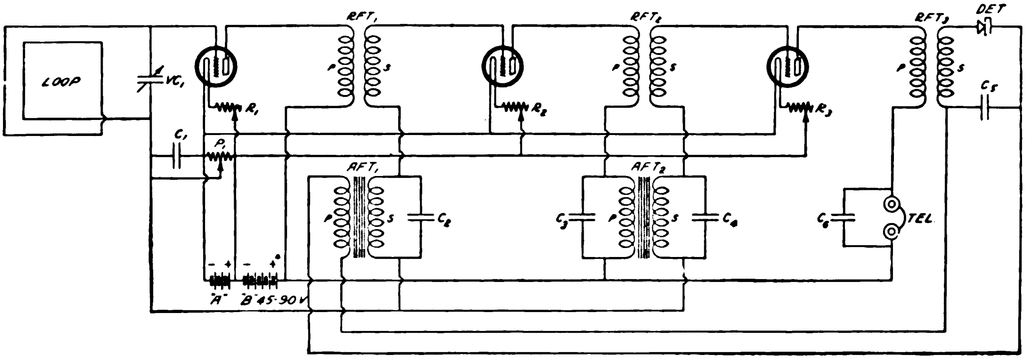
Selectivity: Excellent.

Operation: Extremely simple. Only one control for wavelength needed and one control for regeneration.

Ease of construction: This is a quite complicated circuit to follow out and to get in operation. There are a number of details that will give the beginner trouble when he first tries to make this set, but they can be overcome.

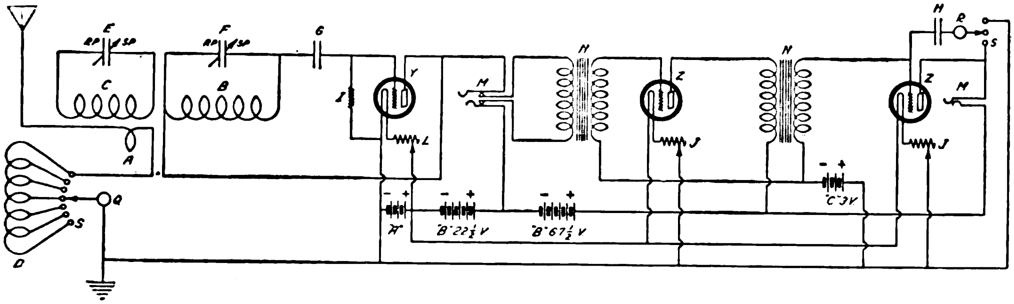
Approximate range: 500 miles (with loop antenna).

Outstanding features: No outdoor antenna is needed for DX reception. Simplicity of tuning. No crystal detector to bother with. The audio-frequency amplification is fed back to the next preceding tube in each stage.



THE SQUIRE REFLEX CIRCUIT

Cost of parts: Not more than $50.00.
Selectivity: Excellent.
Operation: Very simple. One control for wavelength and one control for regeneration; the only other adjustment that must be made is the setting of the crystal detector.
Ease of construction: More or less complicated. There are a number of precautions that must be taken to get the circuit to operate at highest efficiency.
Approximate range: 500 miles (with the loop antenna).
Outstanding features: No outdoor antenna is needed for DX reception. Simplicity of tuning.



THE THREE-TUBE, 4-CIRCUIT TUNER

Cost of parts: Not more than $40.00.

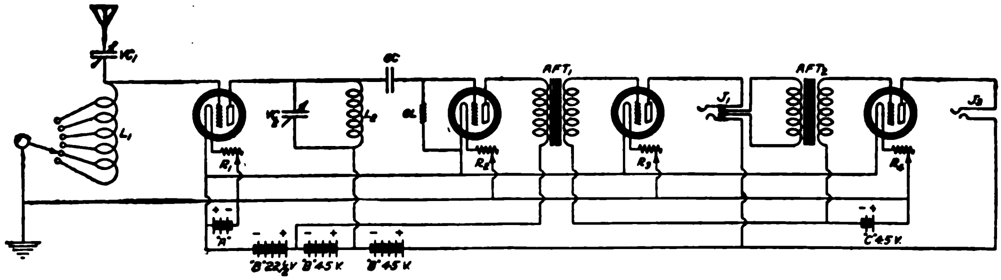
Selectivity: Excellent.

Operation: Very simple. There is one dial which controls the wavelength and one dial which controls regeneration. This dial can be set for the whole band of wavelengths over which regeneration will be constant.

Ease of construction: Not complicated. Be sure that the best parts are obtained, and the results will exceed expectations. Poor parts will render the circuit useless.*
Approximate range: 2,400 miles.
Outstanding features: Loudspeaker reception from distant broadcasting. Regeneration is independent of wavelength. Best sensitivity and selectivity.

(See* **Popular Radio, *May, 1923; also August, 1923, page 165, for constructional details.)*

Four-tube Circuits



ONE STAGE OF TUNED-RADIO-FREQUENCY, DETECTOR AND TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $30.00.

Selectivity: Good.

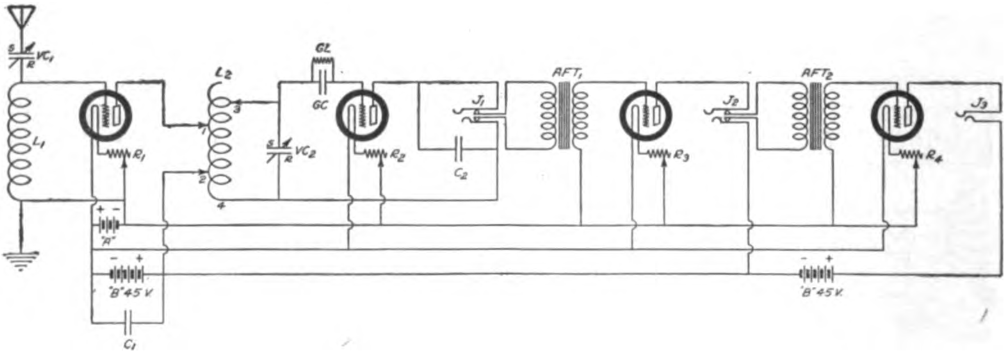
Operation: Not difficult to tune.

Construction: Not any more complicated than the ordinary 3-tube regenerative receiver.*

Approximate range: 2,000 miles.

Outstanding features: Good on DX reception. No potentiometer used. Truthful reproduction.

(See Popular Radio, May, 1924, pages 446-7, for constructional details.)



ABELE CIRCUIT COMPRISING ONE STAGE OF TUNED-RADIO-FREQUENCY AMPLIFICATION, VACUUM-TUBE DETECTOR AND TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $35.00.

Selectivity: Very good.

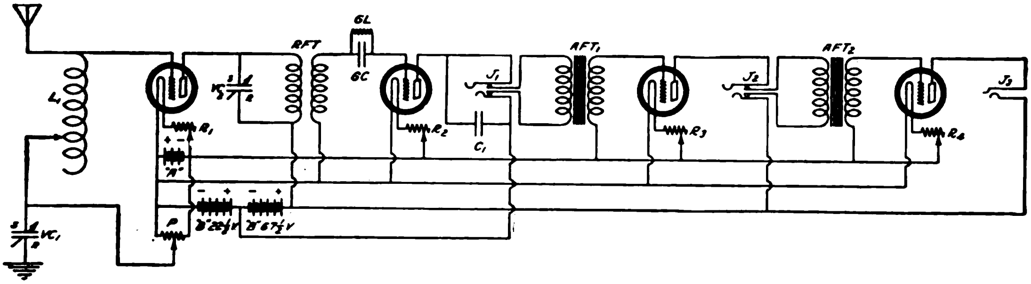
Operation: Fairly complicated.

Construction: Rather difficult to make.*

Approximate range: 2,000 miles.

Outstanding features: Tuned-radio-frequency amplification is employed with a novel means for coupling the plate circuits of the radio-frequency amplifier tube and the detector tube together, to obtain regeneration.

(See Popular Radio, May, 1924, pages 502-3, for constructional details.)

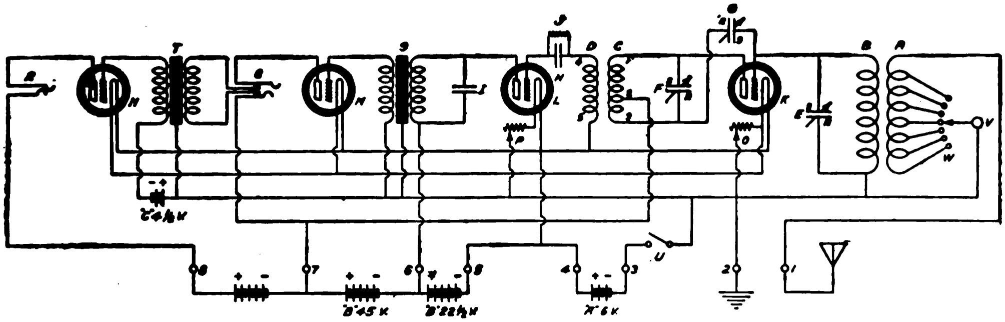


SINGLE-STAGE RADIO-FREQUENCY AMPLIFIER WITH TUNED-PLATE CIRCUIT, DETECTOR, AND TWO-STAGE AUDIO-FREQUENCY AMPLIFIER

Cost of parts: Not more than $45.00.
Selectivity: Very good.
Operation: Simple.
Ease of construction: Not any more complicated than the regular regenerative 3-tube circuit.*

Approximate range: 2,000 miles.
Outstanding features: Particularly good for DX reception of broadcasting. Simple to handle and truthful in reproduction of musical programs.

*(See POPULAR RADIO, *November, 1923, page 420, for ccnstructional details.)*

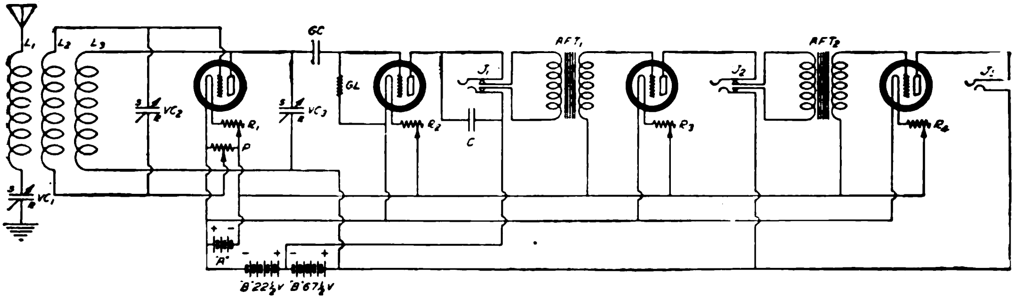


THE CRAIG CIRCUIT, EMPLOYING THE PRINCIPLE OF TUBE-CAPACITY NEUTRALIZATION

Cost of parts: Not more than $70.00.
Selectivity: Excellent.
Operation: Easy to tune. Two dials on the variable condensers tune the input and the output circuits of the radio-frequency tube.

Construction: Not hard to build.*
Approximate range: Up to 3,000 miles.
Outstanding features: Exceptional volume. DX reception and clarity of reception. Does not radiate.

*(See POPULAR RADIO, *April, 1924, page 378, for constructional details.)*



ONE STAGE OF TUNED-RADIO-FREQUENCY AMPLIFICATION, VACUUM TUBE DETECTOR AND TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION EMPLOYING HONEYCOMB COILS FOR TUNING

Cost of parts: Not more than $46.00.

Selectivity: Good.

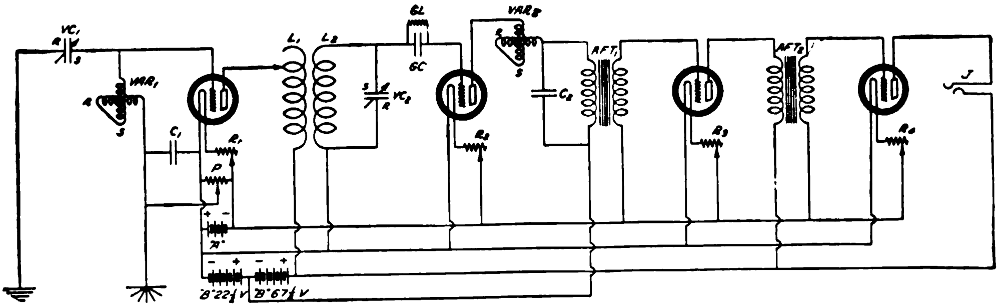
Operation: Fairly complicated.

Construction: Not easy to build.*

Approximate range: 2,400 miles.

Outstanding features: With few additions, this set can be made from the standard triple-coil hook-up. It is good on distance reception.

*(See Popular Radio, July, 1924, pages 78-9, for constructional details.)



ONE STAGE OF TUNED-RADIO-FREQUENCY AMPLIFICATION, WITH A VACUUM-TUBE DETECTOR AND TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $50.00.

Selectivity: Excellent.

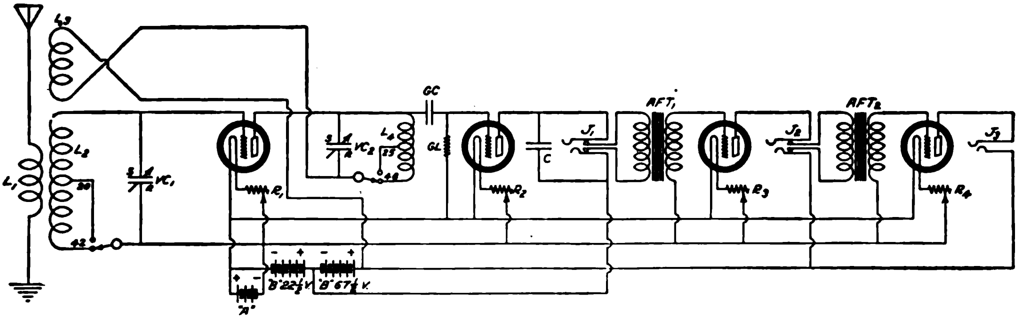
Operation: Not hard to tune. Some experience will have to be gotten, however, before the operator will be able to get the most out of the set.

Construction: Rather complicated. The layout of the set should be carefully studied before it is finally decided upon.*

Approximate range: 500 miles.

Outstanding features: The set will operate without an antenna and employs two grounds or a ground and a short piece of wire acting as a counterpoise. It tunes extremely sharp, and will operate a loud-speaker.

*(See Popular Radio, November, 1923, pages 374-5, for constructional details.)



THE SUPERDYNE CIRCUIT WHICH EMPLOYS A REVERSED-TICKLER FEED-BACK FOR ELIMINATING REGENERATION

Cost of parts: Not more than $47.00.

Selectivity: Excellent.

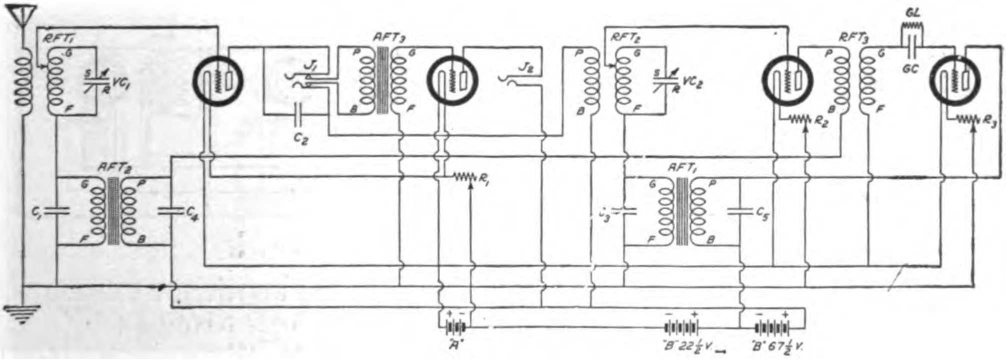
Operation: Rather complicated. The operator will have to get used to the proper adjustment of the tickler before he will get good results, but when this has been learned, the set will function nicely.

Construction: Fairly complicated.*

Approximate range: 2,000 miles.

Outstanding features: Excellent selectivity and sensitivity.

*(See POPULAR RADIO, *March, 1924, pages 296-7, for constructional details.)*



GRIMES INVERSE-REFLEX

Using two stages of tuned-radio-frequency amplification, one stage of transformer-coupled radio-frequency amplification, vacuum-tube detector, and two stages of audio-frequency amplification.

Cost of parts: Not more than $55.00.

Selectivity: Very good.

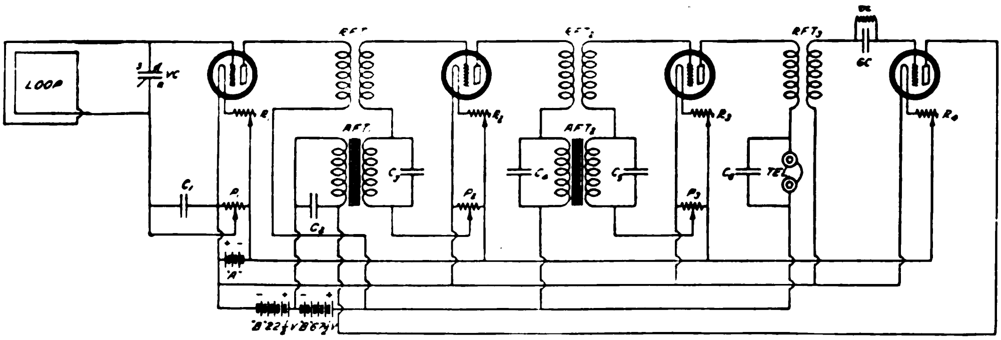
Operation: Not complicated. Two controls.

Construction: More or less complicated. There are a number of precautions that must be taken to get the circuit to function properly.*

Approximate range: 2,000 miles.

Outstanding features: Simplicity of control, and sensitivity to weak signals, as well as being economical from a tube standpoint.

*(See POPULAR RADIO, *April, 1924, page 398, for constructional details.)*

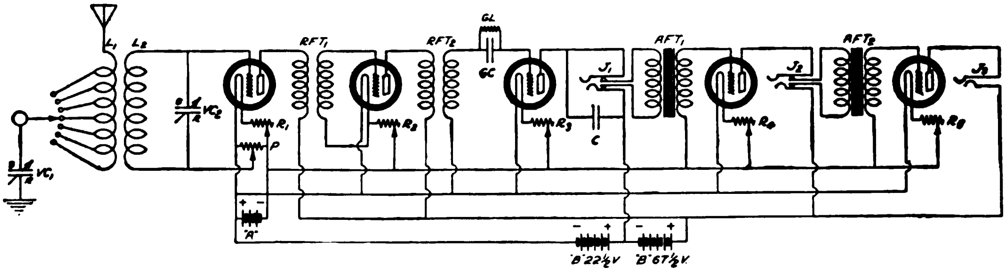


FOUR-TUBE REFLEX WITH THREE STAGES OF RADIO-FREQUENCY AMPLIFICATION, VACUUM-TUBE DETECTOR AND TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $60.00.
Selectivity: Excellent.
Operation: Very simple. Just one control for tuning—a variable condenser connected in shunt to the loop. Regeneration is controlled in the radio-frequency circuits by means of potentiometers.
Ease of construction: More or less complicated. There are a number of precautions that must be taken to get the circuit to function properly.*
Approximate range: 1,000 miles (on a loop antenna).
Outstanding features: No outdoor antenna needed for DX reception. Simplicity of tuning. No crystal detector to bother with.

*(See POPULAR RADIO, *November, 1923, page 418, for constructional details.)*

Five-tube Circuits



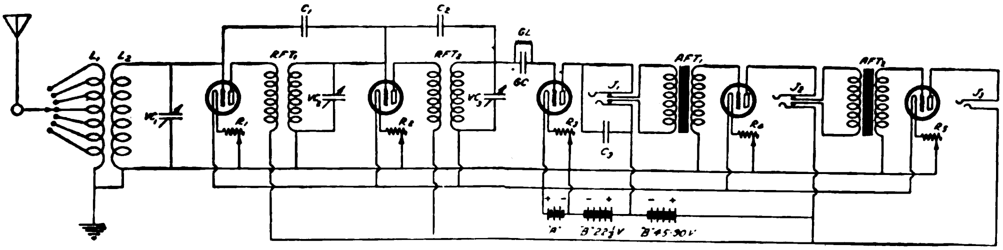
TWO STAGES OF TRANSFORMER-COUPLED RADIO-FREQUENCY AMPLIFICATION WITH VACUUM-TUBE DETECTOR AND TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $54.00
Selectivity: Good.
Operation: Easy to tune. The two variable condensers control tuning. Coupling is varied by means of the variocoupler, and regeneration in the first stage is controlled with the potentiometer.
Construction: More or less complicated. There are a number of precautions that should be taken to get the circuit to function properly.*

Approximate range: 1,500 miles.

Outstanding features: Only two dials for changes of wavelength. The coupling can be set for the desired degree of selectivity and then all other tuning can be accomplished with the two condensers.

*(See POPULAR RADIO, *June, 1924, pages 610-1, for constructional details.)*



FIVE-TUBE NEUTRODYNE

Cost of parts: Not more than $60.00.

Selectivity: Very good. There are three controls for wavelength.

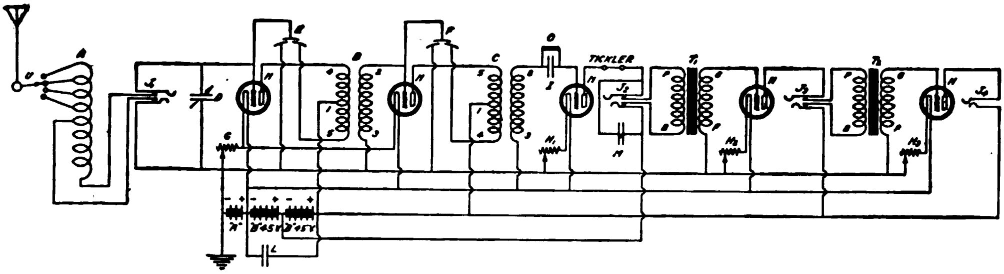
Operation: Simple, if the set is tuned by means of a chart. In fact this is the only way to tune this receiver successfully.

Ease of construction: More or less complicated. There are a number of precautions that must be taken to get the circuit to function properly, especially in the matter of eliminating feedback. The set will operate more efficiently when the neutralizing condensers are upset slightly so that the set will regenerate without readily bursting into uncontrolled oscillation.*

Approximate range: 2,400 miles.

Outstanding features: The wavelength can be calibrated. The set will not re-radiate. Anyone can operate the set by means of the tuning chart.

*(*See* Popular Radio, *September, 1923, page 248, for constructional details.)*



MODIFIED ACMEDYNE CIRCUIT WITH TWO STAGES OF COMPENSATED RADIO-FREQUENCY AMPLIFICATION AND TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $60.00.

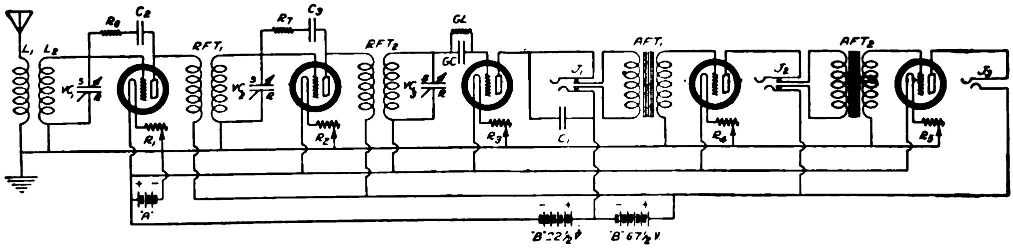
Selectivity: Wonderful.

Operation: Rather complicated for the beginner, but the correct method can be acquired in a month's practice in tuning.

Ease of construction: This, of course, is a complicated circuit to follow out and to get going properly, but it can be done and the set is well worth while.

Approximate range: 2,500 miles.

Outstanding features: Extremely sharp tuning, DX reception and clarity of signals. The trouble encountered in most radio-frequency-amplification circuits, that of properly controlling or eliminating oscillation, is definitely taken out of this circuit by an ingenious device called a compensating condenser which has three plates attached respectively to the grid, filament, and plate circuits of the vacuum tubes.



THE PLIODYNE PRINCIPLE INCORPORATED INTO A RADIO-FREQUENCY CIRCUIT WITH VACUUM-TUBE DETECTOR AND TWO-STAGE AUDIO-FREQUENCY AMPLIFIER

Cost of parts: Not more than $60.00.

Selectivity: Very good.

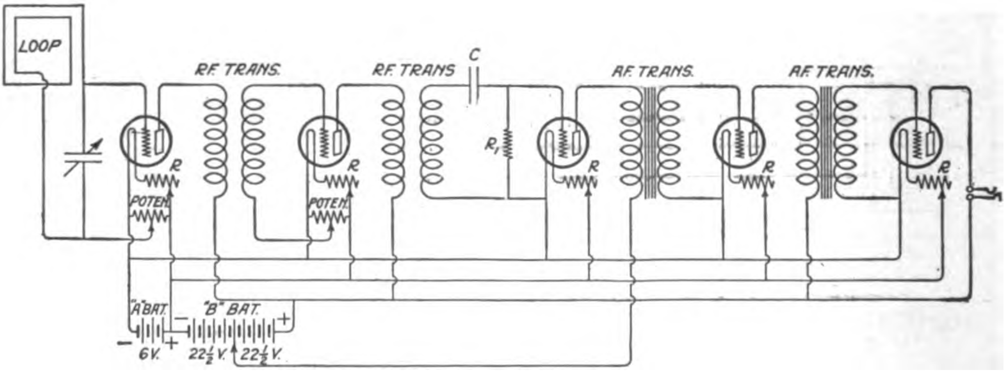
Operation: Not very difficult to tune. Three variable condensers, which are set at practically the same settings, control the tuning.

Construction: Complicated.*

Approximate range: 2,400 miles

Outstanding features: Oscillation and regeneration are prevented by means of "phasing out." The set will not radiate.

*(See POPULAR RADIO, *May, 1924, pages 500-1, for constructional details.)*



TWO STAGES OF RADIO, DETECTOR, AND TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $50.00.

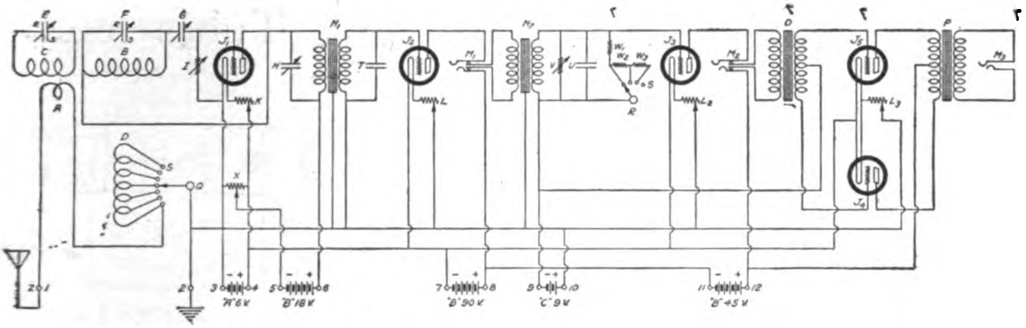
Selectivity: Good.

Operation: Simple. Only one control for tuning the variable condenser. The two potentiometers are used as stabilizers for the control of regeneration in the radio-frequency stages.

Ease of construction: More or less complicated. There are a number of precautions that must be taken to get the circuit to function properly.

Approximate range: 500 miles (on a loop antenna).

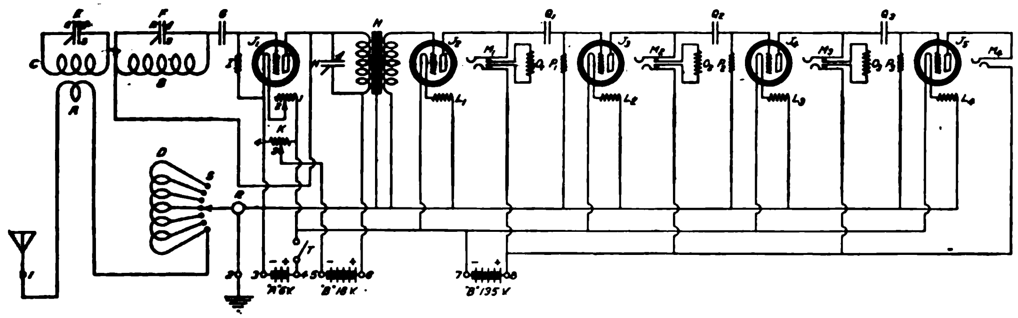
Outstanding features: No outdoor antenna necessary and simplicity of tuning.



THE FOUR-CIRCUIT TUNER WITH TWO STAGES OF STRAIGHT TRANSFORMER-COUPLED AMPLIFICATION, AND ONE STAGE OF PUSH-PULL AMPLIFICATION

Cost of parts: Not more than $90.00.
Selectivity: Excellent.
Operation: Simple to tune.
Construction: Some experience in wiring up the circuit is necessary.*
Approximate range: 3,400 miles.
Outstanding features: Selectivity. Ease of tuning. Good reproduction.

*(See Popular Radio, *January, 1924, page 23, for constructional details.)*



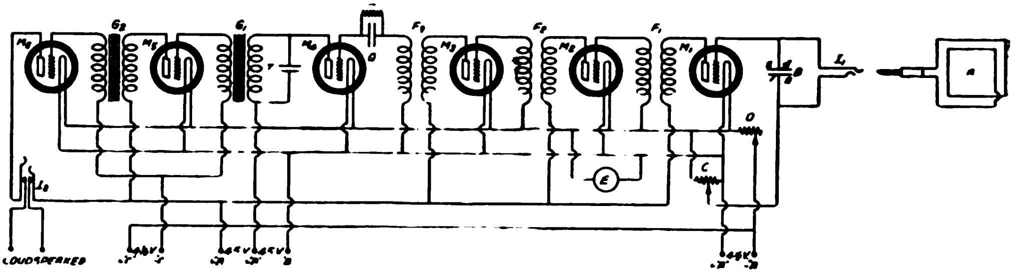
FOUR-CIRCUIT TUNER WITH ONE STAGE OF TRANSFORMER-COUPLED AND THREE STAGES OF RESISTANCE-COUPLED AMPLIFICATION

Cost of parts: Not more than $55.00.
Selectivity: Excellent.
Operation: Simple to tune.
Construction: Not difficult.*
Approximate range: 3,400 miles.
Outstanding features: Increased selectivity.

Ease of tuning and wonderful reproduction are possible with this receiver. In fact, with this particular circuit there has been no other receiver ever tested in Popular Radio Laboratory that can beat it as to truthful and pleasing reproduction of speech and music.

*(See Popular Radio, *October, 1924, page 378, for constructional details.)*

Circuits of More Than Five Tubes



THE POPULAR RADIO PORTABLE

Cost of parts: Not more than $100.00 (complete with tubes, batteries and loudspeaker).

Selectivity: Good.

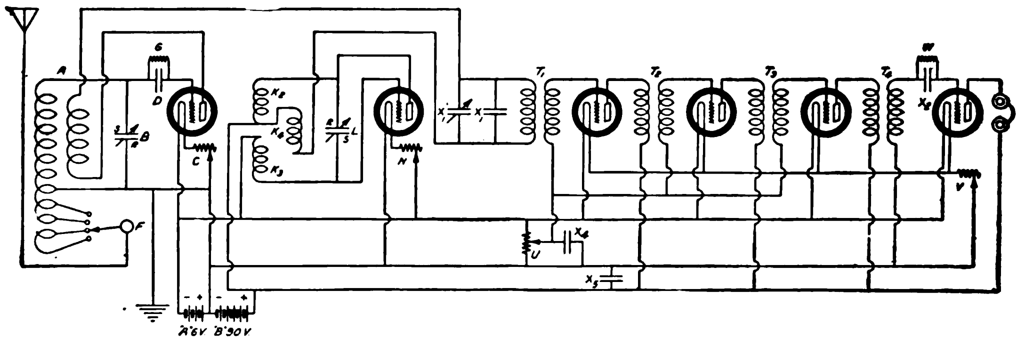
Operation: Extremely simple. All tuning is done with the variable condenser, and regeneration in the first tube circuit is controlled by the potentiometer.

Construction: Not difficult, but there is a lot of work necessary.*

Approximate range: Up to 1,500 miles.

Outstanding features: Portability. All batteries and tubes and loudspeaker contained in carrying case. Simplicity of operation.

**(See* Popular Radio, *July, 1924, page 60, for constructional details.)*



A SUPERHETERODYNE CIRCUIT FOR AIR-CORE INTERMEDIATE-WAVE TRANSFORMERS

Cost of parts: Not more than $80.00.

Selectivity: Very good.

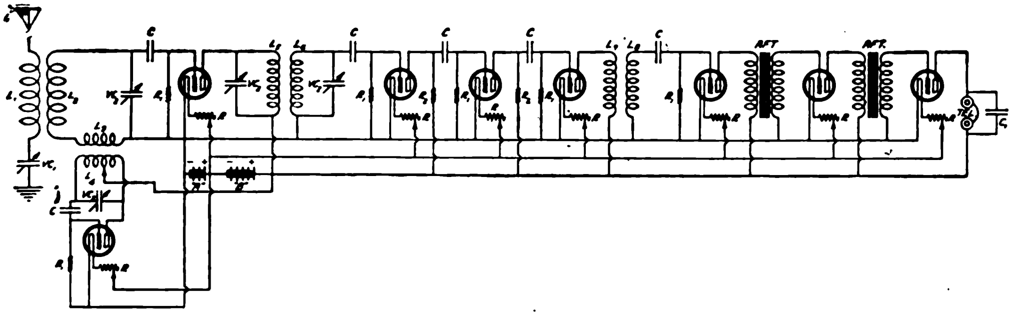
Operation: Not difficult to tune, when the mode of operation is learned.

Construction: Rather complicated.*

Approximate range: 3,400 miles.

Outstanding features: Easier to tune than most complicated circuits. Good distance and selectivity.

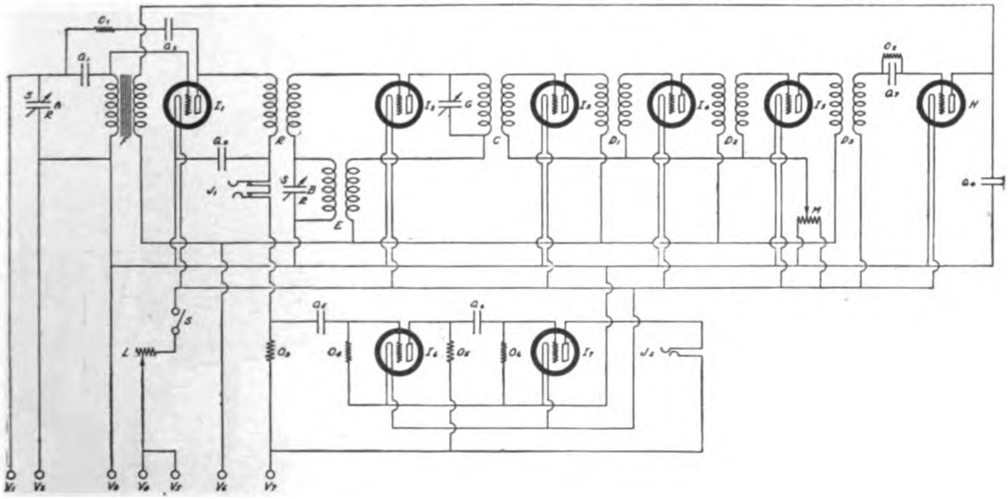
**(See* Popular Radio, *September, November and December, 1923, issues, for constructional details.)*



A RESISTANCE-COUPLED SUPERHETERODYNE WITH TWO STAGES OF AUDIO-FREQUENCY AMPLIFICATION

Cost of parts: Not more than $80.00.
Selectivity: Excellent.
Operation: Difficult.
Construction: A very complicated circuit to master.*
Approximate range: 3,000 miles.
Outstanding feature: This set combines sensitivity with great selectivity.

*(*See* Popular Radio, *June, 1923, pages 468-9, for constructional details.)*



8-TUBE SUPERHETERODYNE REFLEX CIRCUIT

Cost of parts: Not more than $80.00.
Selectivity: Excellent.
Operation: Rather simple.
Construction: A complicated circuit to put together and get into proper operation.*
Approximate range: 3,500 miles.
Outstanding features: This receiver has an exceptional range on a loop. Its tone quality is good and the directional effect of loop tuning helps to cut out a large percentage of interference that could not be eliminated through ordinary tuning means. Needs no outdoor antenna.

*(*See* Popular Radio, *January, 1925, page 36, for constructional details.)*

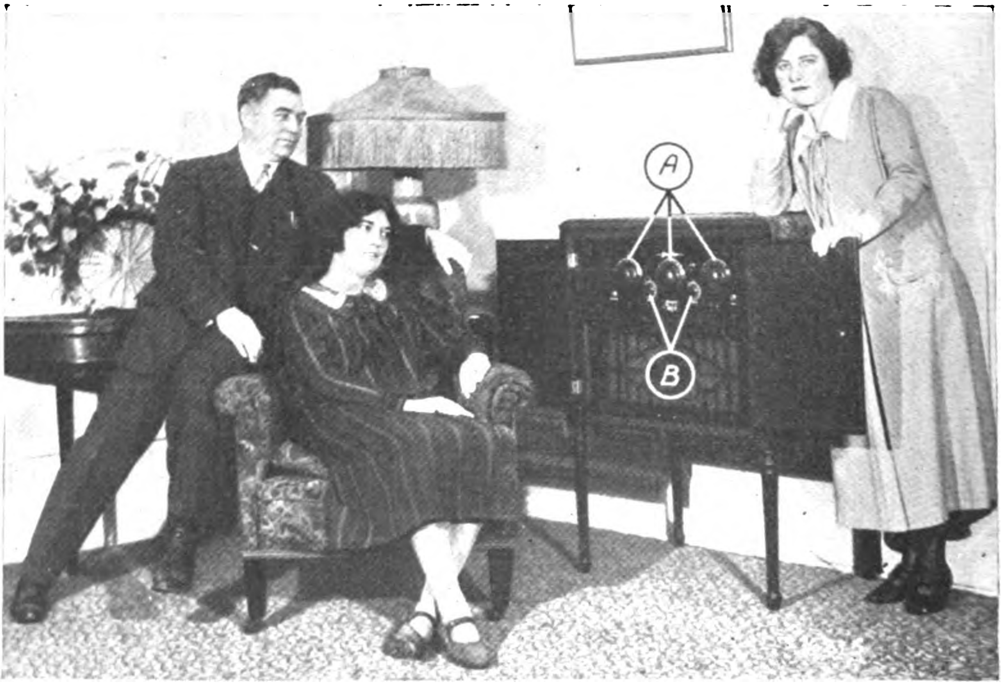
"What Set Shall I Buy?"

2nd Installment

For the guidance of readers who want specific and authoritative information concerning the best of the ready-made receivers that are now on the market, this feature will be published monthly until all of the receivers that have passed the tests of the POPULAR RADIO LABORATORY have been included

The Standardyne Receiver

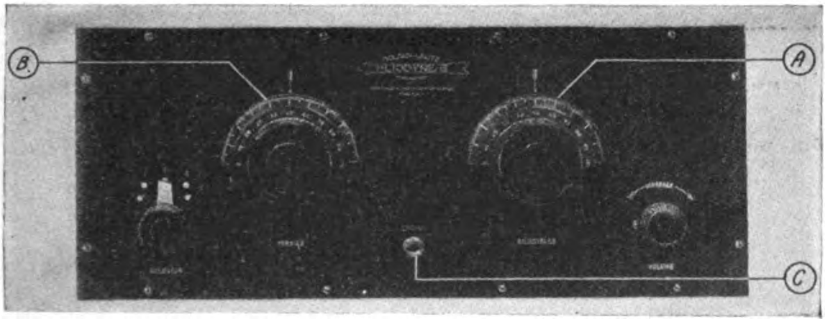
MANUFACTURER'S NAME; The Standard Radio & Electric Company
MODEL; type C
NUMBER OF TUBES; six
TYPE OF TUNING; tuned-radio-frequency
TYPE OF DETECTOR; C-300 or UV-200
RANGE ON PHONES; 3,000 miles
RANGE ON LOUDSPEAKER; 2,500 miles
COST COMPLETE; $250.00
ANTENNA RECOMMENDED; loop
KIND OF TUBES FOR R. F.; C-301-a or UV-201-a
DETECTOR TUBE; C-300 or UV-200
AUDIO TUBES; C-301-a or UV-201
TYPE OF "A" BATTERY; storage
TYPE OF "B" BATTERY; dry-cells
DETECTOR "B" VOLTAGE; 22½-volt
WAVELENGTH RANGE; 220 to 550 meters
NUMBER OF TUNING CONTROLS; two
"A" BATTERY CURRENT USED; 6¼ amperes
"B" BATTERY CURRENT USED; 1¾ amperes.



Underwood & Underwood

HOW THE RECEIVER LOOKS, COMPLETE IN A CABINET

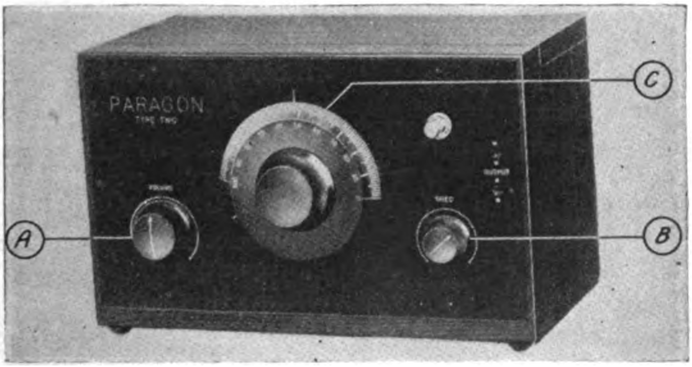
In this set the batteries, the loudspeaker and the set itself are completely installed in a neat cabinet with two doors which open outward in front. The controls on the receiver consist of the three tuning controls A and the two rheostats B.



A and B are the tuning dials. C is the loudspeaker jack.

The Pliodyne Receiver

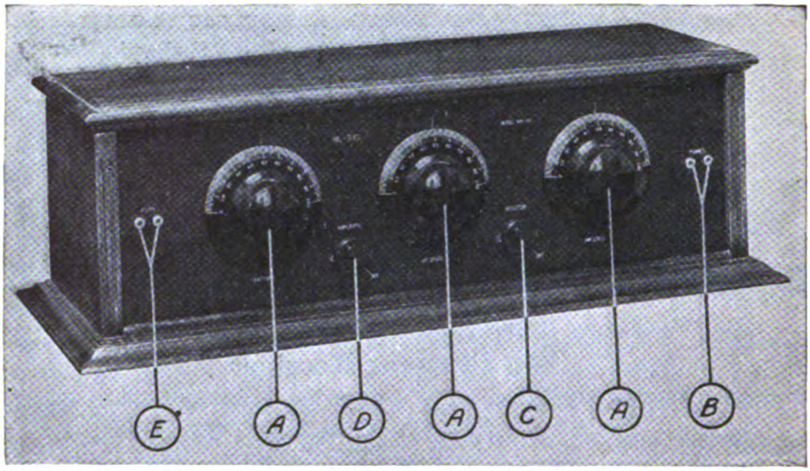
Manufacturer's Name; Golden Leutz, Incorporated
Model; Number six
Number of Tubes; six
Type of Tuning; tuned-radio-frequency
Type of Detector; UV-200 or 201-a
Range on Phones; 3,000 miles
Range on Loudspeaker; 2,000 miles
Cost Complete; $150.00
Antenna Recommended; outdoor
Kind of Tubes for R. F.; UV-201-a
Detector Tube; UV-200 or 201-a
Audio Tubes; UV-201-a
Type of "A" Battery; 6-volt storage
Type of "B" Battery; two 45-volt and one 22½-volt
Detector "B" Voltage; 22½-volt
Wavelength Range; 200 to 546 meters
Number of Tuning Controls; two
"A" Battery Current Used; 1½ to 2½ amperes
"B" Battery Current Used; 30 milliamperes.



A is the volume control. B is the detector rheostat. C is the tuning dial.

Paragon Type Two Receiver

Manufacturer's Name; Adams-Morgan Co., Inc.
Model; Type two
Number of Tubes; two
Type of Tuning; capacity
Type of Detector; vacuum tube
Range on Phones; none specified
Range on Loudspeaker; none specified
Cost, Bare Receiver; $27.50
Antenna Recommended; 100 ft.
Kind of Tubes for R. F.; standard tubes
Detector Tube; standard tube
Audio Tube; standard tube
Type of "A" Battery; standard tubes
Type of "B" Battery; standard tubes
Detector "B" Voltage; 20-45 volts
Wavelength Range; 200 to 580 meters
Number of Tuning Controls; one
"A" Battery Current Used; ½-ampere
"B" Battery Current Used; 6 milliamperes.



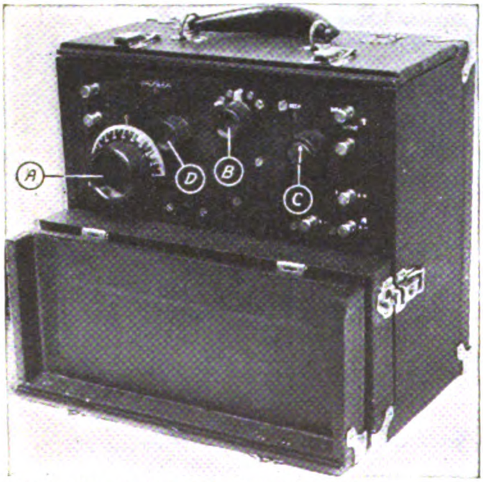
A are the three tuning dials. B are the plugs for the phones. C and D are the rheostats and E are the loudspeaker jacks.

Mu-Rad MA-20 Receiver

Manufacturer's Name; Mu-Rad Laboratories, Inc.
Model; MA-20
Number of Tubes; five
Type of Tuning; three dials; tuned-radio-frequency
Type of Detector; vacuum tube
Range on Phones; not used
Range on Loudspeaker; 1,000 miles
Cost Without Horn; $238.00
Antenna Recommended; single outside wire
Kind of Tubes for R. F.; C-301-a
Detector Tube; C-299
Audio Tubes; C-301-a
Type of "A" Battery Used; none
Type of "B" Battery Used; *none*
Detector "B" Voltage; 36 volts
Wavelength Range; 200 to 600 meters
Number of Tuning Controls; three

Operates with Mu-Rad Recto-filter from 110-volt, 60-cycle light socket.

The Crosley Portable Receiver



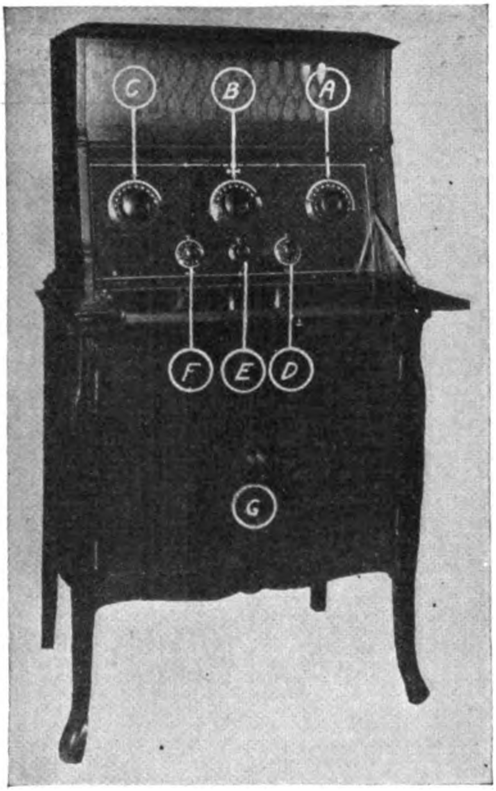
From a photograph made for Popular Radio

Note the tuning control A, the antenna inductance switch B, the rheostat C and a tickler D.

Manufacturer's Name; The Crosley Radio Corporation
Model; Number 51
Number of Tubes; two
Type of Tuning; regenerative
Type of Detector; vacuum tube
Range on Phones; 1,500 miles
Range on Loudspeaker; 1,000 miles
Cost Complete; $30.25
Antenna Recommended; outdoor
Detector Tube; any standard detector tube
Audio Tubes; any standard amplifier tube
Type of "A" Battery; to suit tubes
Type of "B" Battery; 90-volt
Detector "B" Voltage; 22½-volt
Wavelength Range; 200 to 600 meters
Number of Tuning Controls; one.

Fada Neutrola-Grand Receiver

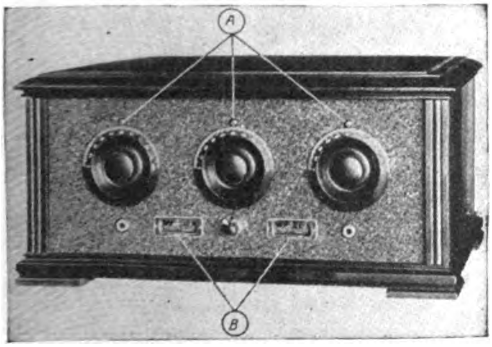
Manufacturer's Name; F. A. D. Andrea, Inc.
Model; Neutrola-Grand, Cat. No. 185/90-A
Number of Tubes; five
Type of Tuning; tuned-radio-frequency (neutrodyne)
Type of Detector; hard tube
Range on Phones; none specified
Range on Loudspeaker; none specified
Cost Complete; $270.00 (without accessories)
Antenna Recommended; 40 to 150 feet
Kind of Tubes for R. F.; UV-201-a, C-301-a, C-299, UV-199
Detector Tube; UV-201-a, C-301-a, C-299, UV-199
Audio Tubes; UV-201-a, C-301-a, C-299, UV-199
Type of "A" Battery; 6-volt storage or 4½-volt dry-cell batteries
Type of "B" Batteries; two 45-volt batteries
Detector "B" Voltage; 22½-volt
Wavelength Range; 200 to 575 meters
Number of Tuning Controls; three
"A" Battery Current Used; 1¼ amperes
"B" Battery Current Used; 7 to 20 milliamperes.



A, B and C are the tuning dials. D, E and F are the rheostats and volume control. G is the container for the batteries.

Eisemann Type 6-D Receiver

Manufacturer's Name; Eisemann Magneto Corporation
Model; Type 6-D
Number of Tubes; five
Type of Tuning; tuned-radio-frequency



A marks the tuning dials and B the rheostats.

Type of Detector; vacuum tube
Range on Phones; none specified
Range on Loudspeaker; none specified
Cost Complete; $125.00 (less accessories)
Antenna Recommended; 75 to 125 feet, single wire
Kind of Tubes for R. F.; UV-201-a
Detector Tube; UV-201-a
Audio Tubes; UV-201-a
Type of "A" Battery; storage, 6-volt
Type of "B" Battery; large size, 90 volts
Detector "B" Voltage; 22½ to 45 volts
Wavelength Range; 200 to 560 meters
Number of Tuning Controls; three
"A" Battery Current Used; 1¼ amperes.
"B" Battery Current Used; 15 milliamperes.

Broadcast Stations in the United States

Call Letters	*Location*	*Wave-length*
KDKA	E. Pittsburgh, Pa.	309
KDLR	Devils Lake, N. D.	231
KDPM	Cleveland, O.	270
KDPT	San Diego, Cal.	244
KDYL	Salt Lake City, Utah	250
KDYM	San Diego, Cal.	280
KDZB	Bakersfield, Cal.	240
KDZE	Seattle, Wash.	270
KDZI	Wenatchee, Wash.	360
KFAD	Phoenix, Ariz.	360
KFAE	Pullman, Wash.	348
KFAF	Denver, Col.	278
KFAJ	Boulder, Col.	360
KFAN	Moscow, Ida.	230
KFAU	Boise, Ida.	271
KFAW	Santa Ana, Cal.	280
KFBB	Havre, Mont.	360
KFBC	San Diego, Cal.	278
KFBE	San Luis Obispo, Cal.	218
KFBG	Tacoma, Wash.	250
KFBK	Sacramento, Cal.	283
KFBL	Everett, Wash.	224
KFBU	Laramie, Wyo.	283
KFCB	Phoenix, Ariz.	238
KFCC	Helena, Mont.	248
KFCF	Walla Walla, Wash.	256
KFCP	Ogden, Utah	360
KFCZ	Omaha, Neb.	258
KFDD	Boise, Ida.	252
KFDH	Tuscon, Ariz.	368
KFDJ	Corvallis, Ore.	254
KFDY	Brookings, S. D.	360
KFIM	Beaumont, Tex.	315
KFDX	Shreveport, La.	360
KFDZ	Minneapolis, Minn.	231
KFEC	Portland, Ore.	248
KFEK	Minneapolis, Minn.	261
KFEL	Denver, Col.	254
KFEQ	Oak, Neb.	268
KFER	Fort Dodge, Ia.	231
KFEY	Kellogg, Ida.	233
KFFP	Moberly, Mo.	266
KFFV	Lamoni, Ia.	280
KFGB	Utica, Neb.	224
KFGC	Baton Rouge, La.	254
KFGD	Chickasha, Okla.	248
KFGH	Stanford Univ., Cal.	273
KFGQ	Boone, Ia.	226
KFHA	Gunnison, Col.	252
KFHH	Neah Bay, Wash.	261
KFHL	Oskaloosa, Ia.	240
KFHR	Seattle, Wash.	283
KFI	Los Angeles, Cal.	468
KFIF	Portland, Ore.	248
KFIO	Spokane, Wash.	252
KFIQ	Yakima, Wash.	242
KFIU	Juneau, Alaska	226
KFIX	Independence, Mo.	240
KFIZ	Fond du Lac, Wis.	273
KFJB	Marshalltown, Ia.	248
KFJF	Oklahoma City, Okla.	252
KFJI	Astoria, Ore.	252
KFJL	Ottumwa, Ia.	242
KFJM	Grand Forks, N. D.	280
KFJR	Stevensville, Mont.	258
KFJX	Cedar Falls, Ia.	280
KFJY	Fort Dodge, Ia.	246
KFKA	Greeley, Col.	273
KFKB	Milford, Kan.	286
KFKQ	Conway, Ark.	250
KFKU	Lawrence, Kan.	275
KFKV	Butte, Mont.	283
KFKX	Hastings, Neb.	288
KFLA	Butte, Mont.	283
KFLB	Menominee, Mich.	248
KFLD	Franklinton, La.	234
KFLE	Denver, Col.	268
KFLP	Cedar Rapids, Ia.	256
KFLR	Albuquerque, N. M.	254
KFLU	San Benito, Tex.	236
KFLV	Rockford, Ill.	229
KFLX	Galveston, Tex.	240
KFLZ	Atlantic, Ia.	273
KFMB	Little Rock, Ark.	254

Location	*Wave-length*	*Call Letters*
AGRICULTURAL COL., N. D.	283	WPAK
AKRON, O.	258	WADC
ALBUQUERQUE, N. M.	254	KFLR
ALLENTOWN, PA.	280	WCBA
ALLENTOWN, PA.	229	WSAN
ALTOONA, PA.	261	WFBG
AMES, IA.	207	WOI
AMARILLO, TEX.	234	WQAC
AMARILLO, TEX.	263	WDAG
ANDERSON, IND.	246	WEBD
ANDERSON, IND.	218	WHBU
ANN ARBOR, MICH.	280	WCBC
ARNOLD, PA.	254	WCBU
ASHLAND, WIS.	233	WJBD
ASTORIA, ORE.	252	KFJI
ATLANTA, GA.	278	WDBE
ATLANTA, GA.	428	WSB
ATLANTIC, IA.	273	KFLZ
ATLANTIC CITY, N. J.	275	WHAR
ATLANTIC CITY, N. J.	300	WPG
AUBURN, ALA.	250	WMAV
BAKERSFIELD, CAL.	240	KDZB
BALTIMORE, MD.	229	WCBM
BALTIMORE, MD.	254	WBGA
BALTIMORE, MD.	275	WCAO
BALTIMORE, MD.	452	WFBR
BANGOR, ME.	240	WABI
BANGOR, ME.	252	WDBN
BERRIEN SPRINGS, MICH.	285	WEMC
BATAVIA, ILL.	275	WORD
BATON ROUGE, LA.	254	KFGC
BEAUMONT, TEX.	315	KFIM
BELDEN, NEB.	273	KFQY
BELLEFONTAINE, O.	222	WHBD
BELOIT, WIS.	283	WEBW
BELVIDERE, ILL,	274	WOAG
BEMIS, TENN.	240	WCBI
BERKELEY, CAL.	275	KRE
BOISE, IDA.	271	KFAU
BOISE, IDA.	252	KFDD
BOONE, IA.	226	KFGQ
BOSTON, MASS.	256	WDBR
BOSTON, MASS.	244	WTAT
BOSTON, MASS.	250	WNAB
BOSTON, MASS.	284	WNAC
BOSTON, MASS.	475	WEEI
BOULDER, COL.	360	KFAJ
BRECKENRIDGE, MINN.	242	KFUJ
BRISTOW, OKLA.	394	KFRU
BROADLANDS, ILL.	233	WSRF
BROOKINGS, S. D.	360	KFDY
BROOKLYN, N. Y.	240	WHAP
BUCK HILL FALLS, PA.	268	WCBY
BUFFALO, N. Y.	319	WGR
BURLINGAME, CAL.	231	KFNZ
BURLINGAME, CAL.	231	KFQH
BURLINGTON, IA.	283	WIAS
BURLINGTON, VT.	250	WCAX
BUTLER, MO.	230	WNAR
BUTLER, PA.	286	WBR
BUTTE, MONT.	254	KFUY
BUTTE, MONT.	283	KFKV
BUTTE, MONT.	283	KFLA
CAMBRIDGE, ILL.	242	WTAP
CAMBRIDGE, O.	248	WEBE
CAMDEN, ARK.	242	KFVC
CAMDEN, N. J.	224	WABU
CANTON, N. Y.	280	WCAD
CANTON, O	245	WHBC
CAPE GIRARDEAU, MO.	275	WSAB
CARTERSVILLE, MO.	268	KFPW
CARTHAGE, ILL.	246	WCAZ
CAZENOVIA, N. Y.	261	WMAC
CEDAR FALLS, IA.	280	KFJX
CEDAR RAPIDS, IA.	256	KFLP
CEDAR RAPIDS, IA.	268	WJAM
CEDAR RAPIDS, IA.	278	WKAA
CHARLESTON, S. C.	268	WBBY
CHARLES TOWN, W. VA.	273	WPAZ
CHARLOTTE, N. C.	275	WBT
CHATTANOOGA, TENN.	256	WDOD
CHESANING, MICH.	227	WHBI
CHICAGO, ILL.	535	KYW
CHICAGO, ILL.	286	WAAF

Wave-length	*Location*	*Call Letters*
200	Joliet, Ill.	WIBD
205	San Pedro, Cal.	KFVD
206	Downers Grove, Ill.	WHBT
207	Ames, Ia.	WOI
208	Hollywood, Cal.	KFVF
209	Martinsburg, W. Va.	WIBE
208	Mechanicsburg, O.	WHBS
209	Fall River, Mass.	WGBH
209	New Bedford, Mass.	WEBH
211	Upland, Cal.	KFWC
212	Punxsutawny, Pa.	WHBX
212	Spring Valley, Ill.	WGBW
214	Ogden, Utah	KFWA
214	St. Louis, Mo.	KFWF
215	Philadelphia, Pa.	WHBW
216	Cincinnati, O.	WHBR
217	Chicago, Ill.	WFKB
217	Evansville, Ind.	WGBF
217	Pullman, Wash.	KFRX
218	Anderson, Ind.	WHBU
218	Flint, Mich.	WTHS
218	Manhattan, Kan.	KFVH
218	R. R. No. 2	WGBY
218	San Luis Obispo, Cal.	KFBE
220	Logansport, Ind.	WHBL
220	Oklahoma City, Okla.	KFQR
220	Olympia, Wash.	KFRW
220	Osseo, Wis.	WTAQ
221	Fort Worth, Tex.	KFQB
222	Bellefontaine, O.	WHBD
222	Cincinnati, O.	WHAG
222	Culver, Ind.	WHBH
222	Elkins Park, Pa.	WIBG
222	Hartington, Neb.	KFRZ
222	Norfolk, Va.	WBBX
222	Rock Island, Ill.	WHBF
222	St. Petersburg, Fla.	WIBC
222	Tacoma Park, Md.	WBES
224	Camden, N. J.	WABU
224	Everett, Wash.	KFBL
224	La Porte, Ind.	WRAF
224	Monmouth, Ill.	WBBU
224	Ogden, Utah	KFUR
224	Seattle, Wash.	KFPB
224	Utica, Neb.	KFGB
224	Wallace, Ida.	KFOD
225	Kenosha, Wis.	WOAR
226	Boone, Ia.	KFGQ
226	Chicago, Ill.	WBBM
226	Chicago, Ill.	WIBO
226	David City, Neb.	KFOR
226	Juneau, Alaska	KFIU
226	Los Angeles, Cal.	KFQG
226	Macon, Ga.	WCBW
226	Marion, Ind.	WIAQ
226	Montgomery, Ala.	WKAN
226	A Portable	WEBM
226	San Jose, Cal.	KFVJ
226	Seymour, Ind.	WFBE
226	St. Paul, Minn.	KFOY
226	St. Petersburg, Fla.	WDBI
226	Thrifton, Va.	WGBG
227	Chesaning, Mich.	WHBI
227	Cleveland, O.	WDBK
227	Elyria, O.	WGBL
227	Indianapolis, Ind.	WBBZ
227	Lake Forest, Ill.	WABA
229	Allentown, Pa.	WSAN
229	Baltimore, Md.	WCBM
229	Graniteville, O.	WJD
229	Lincoln, Neb.	WJAB
229	Marshfield, Wis.	WGBR
229	Pasadena, Cal.	KPPC
229	Roanoke, Va.	WDBJ
229	Rockford, Ill.	KFLV
229	Taunton, Mass.	WDBB
230	Butler, Mo.	WNAR
230	Moscow, Ida.	KFAN
231	Burlingame, Cal.	KFNZ
231	Burlingame, Cal.	KFQH
231	Devils Lake, N. D.	KDLR
231	Ellsworth, Me.	WHBK
231	Fort Dodge, Ia.	KFER
231	Greencastle, Ind.	WLAX

Call Letters	Location	Wave-length
KFMQ	Fayetteville, Ark.	299
KFMR	Sioux City, Ia.	261
KFMT	Minneapolis, Minn.	231
KFMW	Houghton, Mich.	266
KFMX	Northfield, Minn.	336
KFNF	Shenandoah, Ia.	266
KFMG	Coldwater, Miss.	254
KFNJ	Warrensburg, Mo.	234
KFNL	Pasa Robles, Cal.	240
KFNV	Santa Rosa, Cal.	234
KFNY	Helena, Mont.	261
KFNZ	Burlingame, Cal.	231
KFOA	Seattle, Wash.	384
KFOC	Whittier, Cal.	236
KFOD	Wallace, Ida.	224
KFOJ	Moberly, Mo.	246
KFOL	Marengo, Ia.	234
KFON	Long Beach, Cal.	234
KFOO	Salt Lake City, Utah	261
KFOP	Marshfield, Ore.	240
KFOR	David City, Neb.	226
KFOT	Wichita, Kan.	231
KFOU	Richmond, Cal.	254
KFOX	Omaha, Neb.	248
KFOY	St. Paul, Minn.	226
KFPB	Seattle, Wash.	224
KFPG	Los Angeles, Cal.	238
KFPH	Salt Lake City, Utah	242
KFPL	Dublin, Tex.	242
KFPM	Greenville, Tex.	242
KFPR	Los Angeles, Cal.	231
KFPT	Salt Lake City, Utah	268
KFPV	San Francisco, Cal.	236
KFPW	Carterville, Mo.	268
KFPY	Spokane, Wash.	283
KFQA	St. Louis, Mo.	264
KFQB	Forth Worth, Tex.	221
KFQC	Taft, Cal.	258
KFQG	Los Angeles, Cal.	226
KFQH	Burlingame, Cal.	231
KFQN	Portland, Ore.	283
KFQP	Iowa City, Ia.	284
KFQR	Oklahoma City, Okla.	220
KFQT	Dennison, Tex.	252
KFQU	Holy City, Cal.	253
KFQW	North Bend, Wash.	248
KFQX	Seattle, Wash.	233
KFQY	Belden, Neb.	273
KFQZ	Hollywood, Cal.	240
KFRJ	Conway, Ark.	250
KFRM	Fort Sill, Okla.	263
KFRO	Fort Worth, Tex.	246
KFRU	Bristow, Okla.	394
KFRW	Olympia, Wash.	220
KFRX	Pullman, Wash.	217
KFRY	State College, N. M.	266
KFRZ	Hartington, Neb.	222
KFSG	Los Angeles, Cal.	272
KFSY	Helena, Mont.	261
KFUJ	Breckenridge, Minn.	242
KFUL	Galveston, Tex.	258
KFUM	Colorado Springs, Col.	242
KFUO	St. Louis, Mo.	549
KFUP	Denver, Col.	234
KFUQ	San Francisco, Cal.	234
KFUR	Ogden, Utah	224
KFUS	Oakland, Cal.	233
KFUT	Salt Lake City, Utah	271
KFUU	San Leandro, Cal.	234
KFUY	Butte, Mont.	254
KFUZ	Virginia, Minn.	248
KFVC	Camden, Ark.	242
KFVD	San Pedro, Cal.	205
KFVK	Sacramento, Cal.	248
KFVF	Hollywood, Cal.	208
KFVJ	San Jose, Cal.	226
KFVH	Manhattan, Kan.	218
KFVI	Houston, Tex.	248
KFVL	Vancouver, Wash.	231
KFWA	Ogden, Utah	214
KFWB	Hollywood, Cal.	252
KFWC	Upland, Cal.	211
KFWF	St. Louis, Mo.	214
KGB	Tacoma, Wash.	252
KGO	Oakland, Cal.	361
KGU	Honolulu, Hawaii	360
KGW	Portland, Ore.	491
KGY	**Lacy, Wash.**	253

Location	Wave-length	Call Letters
CHICAGO, ILL.	226	WBBM
CHICAGO, ILL.	266	WBCN
CHICAGO, ILL.	258	WDBY
CHICAGO, ILL.	217	WFKB
CHICAGO, ILL.	370	WEBH
CHICAGO, ILL.	266	WENR
CHICAGO, ILL.	370	WGN
CHICAGO, ILL.	233	WHBM
CHICAGO, ILL.	226	WIBO
CHICAGO, ILL.	268	WJAZ
CHICAGO, ILL.	344	WLS
CHICAGO, ILL.	447	WMAQ
CHICAGO, ILL.	250	WMBB
CHICAGO, ILL.	268	WTX
CHICAGO, ILL.	447	WQJ
CHICKASHA, OKLA.	248	KFGD
CINCINNATI, O.	248	WAAD
CINCINNATI, O.	309	WFBW
CINCINNATI, O.	222	WHAG
CINCINNATI, O.	216	WHBR
CINCINNATI, O.	422	WLW
CINCINNATI, O.	321	WMH
CINCINNATI, O.	325	WSAI
CLEMSON COL., S. C.	331	WBAC
CLEMSON COL., S. C.	336	WSAC
CLEVELAND, O.	270	KDPM
CLEVELAND, O.	227	WDBK
CLEVELAND, O.	389	WEAR
CLEVELAND, O.	273	WHK
CLEVELAND, O.	389	WTAM
COLDWATER, MISS.	254	KFNG
COL. STATION, TEX.	280	WTAW
COLLEGEVILLE, MINN.	236	WFBJ
COLORADO SPRINGS, COL.	242	KFUM
COLUMBIA, MO.	254	WAAN
COLUMBIA, TENN.	268	WDBW
COLUMBUS, GA.	236	WDBA
COLUMBUS, GA.	244	WHBV
COLUMBUS, O.	292	WBAV
COLUMBUS, O.	286	WCAH
COLUMBUS, O.	293	WEAO
COLUMBUS, O.	286	WMAN
COLUMBUS, O.	286	WPAL
CONWAY, ARK.	250	KFKQ
CONWAY, ARK.	250	KFRJ
CORVALLIS, ORE.	254	KFDJ
CRANSTON, R. I.	440	WDWF
CRANSTON, R. I.	234	WKAP
CRANSTON, R. I.	286	WKBF
CULVER, IND.	222	WHBH
DALLAS, TEX.	472	WFAA
DALLAS, TEX.	261	WRR
DARTMOUTH, MASS.	360	WMAF
DAVENPORT, IA.	484	WOC
DAVID CITY, NEB.	226	KFOR
DAYTON, O.	283	WDBS
DAYTON, O.	270	WEBT
DEARBORN, MICH.	273	WWI
DECATUR, ILL.	360	WBAO
DEERFIELD, ILL.	238	WHT
DENNISTON, TEX.	252	KFQT
DENVER, COL.	278	KFAF
DENVER, COL.	254	KFEL
DENVER, COL.	268	KFLE
DENVER, COL.	234	KFUP
DENVER, COL.	283	KLZ
DENVER, COL.	323	KOA
DES MOINES, IA.	526	WHO
DETROIT, MICH.	286	KOP
DETROIT, MICH.	516	WCX
DETROIT, MICH.	352	WWJ
DEVILS LAKE, N. D.	231	KDLR
DOWNERS GROVE, ILL.	206	WHBT
DUBLIN, TEX.	242	KFPL
EAST LANSING, MICH.	285	WKAR
EAST PITTSBURGH, PA.	309	KDKA
EAST PROVIDENCE, R. I.	240	WKAD
ELGIN, ILL.	278	WCEE
ELGIN, ILL.	303	WTAS
ELKINS PARK, PA.	222	WIBG
ELLSWORTH, ME.	231	WHBK
EL PASO, TEX.	268	WDAH
ELYRIA, O.	227	WGBL
ERIE, PA.	242	WOAV
ESCANABA, MICH.	256	WRAK
EUREKA, ILL.	240	WFBB
EVANSVILLE, IND.	217	WGBF
EVERETT, WASH.	224	KFBL

Wave-length	Location	Call Letters
231	Harrisburg, Pa.	WHBG
231	Los Angeles, Cal.	KFPR
231	Minneapolis, Minn.	KFDZ
231	Minneapolis, Minn.	KFMT
231	Pawtucket, R. I.	WHBO
231	Streator, Ill.	WTAX
231	Vancouver, Wash.	KFVL
231	Webster, Mass.	WKBE
231	Wheatland, Wis.	WIBF
231	Wichita, Kan.	KFOT
231	Wilkes-Barre, Pa.	WBRE
233	Ashland, Wis.	WJBD
233	Broadlands, Ill.	WSRF
233	Chicago, Ill.	WHBM
233	Highland Park, N. J.	WEBA
233	Kellogg, Ida.	KFEY
233	Kingston, N. Y.	WDBZ
233	Memphis, Tenn.	WHBQ
233	Newark, N. J.	WCBX
233	New York, N. Y.	WDBX
233	Oakland, Cal.	KFUS
233	Port Chester, N. Y.	WSAY
233	Port Huron, Mich.	WAFD
233	Seattle, Wash.	KFQX
234	Amarillo, Tex.	WQAC
234	Cranston, R. I.	WKAP
234	Denver, Col.	KFUP
234	Fort Wayne, Ind.	WHBJ
234	Franklinton, La.	KFLD
234	La Salle, Ill.	WJBC
234	Long Beach, Cal.	KFON
234	Marengo, Ia.	KFOL
234	McKeesport, Pa.	WIK
234	Menominee, Wis.	WGBQ
234	Philadelphia, Pa.	WFBD
234	Providence, R. I.	WGBM
234	Salem, N. J.	WDBQ
234	San Francisco, Cal.	KFUQ
234	San Leandro, Cal.	KFUU
234	Santa Rosa, Cal.	KFNV
234	Warrensburg, Mo.	KFNJ
234	Washington, D. C.	WDM
234	Wooster, O.	WABW
236	Collegeville, Minn.	WFBJ
236	Columbus, Ga.	WDBA
236	Greenville, S. C.	WGBT
236	Madison, Wis.	WIBA
236	Nashville, Tenn.	WCBQ
236	Pittsburgh, Pa.	WCBF
236	Richmond Hill, N. Y.	WBOQ
236	San Benito, Tex.	KFLU
236	San Francisco, Cal.	KFPV
236	Waterloo, Ia.	WRAN
236	Whittier, Cal.	KFOC
228	Deerfield, Ill.	WHT
236	Los Angeles, Cal.	KFPG
236	Phoenix, Ariz.	KFCB
238	Reading, Pa.	WRAW
238	Worcester, Mass.	WCBT
240	Bakersfield, Cal.	KDZB
240	Bangor, Me.	WABI
240	Bemis, Tenn.	WCBI
240	Brooklyn, N. Y.	WHAP
240	Eureka, Ill.	WFBB
240	East Providence, R. I.	WKAD
240	Galveston, Tex.	KFLX
240	Hollywood, Cal.	KFQZ
240	Independence, Mo.	KFIX
240	Marshfield, Ore.	KFOP
240	Oskaloosa, Ia.	KFHL
240	Owosso, Mich.	WSMH
240	Paso Robles, Cal.	KFNL
240	Rapid City, S. D.	WCAT
240	Sandusky, O.	WABH
240	San Jose, Cal.	KQW
240	Scranton, Pa.	WGBI
240	Stevens Point, Wis.	WHBB
240	Trenton, N. J.	WOAX
240	Winter Park, Fla.	WDBO
242	Breckenridge, Minn.	KFUJ
242	Cambridge, Ill.	WTAP
242	Camden, Ark.	KFVC
242	Colorado Springs, Col.	KFUM
242	Dublin, Tex.	KFPL
242	Erie, Pa.	WOAV
242	Greenville, Tex.	KFPM
242	Joliet, Ill.	WWAE
242	Oakland, Cal.	KLS

Call Letters	Location	Wave-length
KHJ	Los Angeles, Cal.	405
KHQ	Seattle, Wash.	273
KJR	Seattle, Wash.	384
KJS	Los Angeles, Cal.	293
KLS	Oakland, Cal.	242
KLX	Oakland, Cal.	508
KLZ	Denver, Col.	283
KMJ	Fresno, Cal.	243
KMO	Tacoma, Wash.	250
KNT	Kukah Bay, Alaska	263
KNX	Los Angeles, Cal.	337
KOA	Denver, Col.	323
KOB	State College, N. M.	348
KOP	Detroit, Mich.	286
KPO	San Francisco, Cal.	428
KPPC	Pasadena, Cal.	229
KQV	Pittsburgh, Pa.	270
KQW	San Jose, Cal.	240
KRE	Berkeley, Cal.	275
KSAC	Manhattan, Kan.	341
KSD	St. Louis, Mo.	545
KSL	Salt Lake City, Utah	299
KTHS	Hot Springs, Ark.	375
KTW	Seattle, Wash.	454
KUO	San Francisco, Cal.	246
KUOM	Missoula, Mont.	244
KWG	Stockton, Cal.	360
KWH	Los Angeles, Cal.	360
KYO	Honolulu, Hawaii	270
KYW	Chicago, Ill.	535
KZM	Oakland, Cal.	360
WAAB	New Orleans, La.	263
WAAC	New Orleans, La.	275
WAAD	Cincinnati, O.	248
WAAF	Chicago, Ill.	286
WAAM	Newark, N. J.	263
WAAN	Columbia, Mo.	254
WAAW	Omaha, Neb.	285
WABA	Lake Forest, Ill.	227
WABB	Harrisburg, Pa.	266
WABH	Sandusky, O.	240
WABI	Bangor, Me.	240
WABL	Sorrs, Conn.	283
WABM	Saginaw, Mich.	254
WABN	LaCrosse, Wis.	244
WABO	Rochester, N. Y.	283
WABQ	Haverford, Pa.	261
WABR	Toledo, O.	270
WABU	Camden, N. J.	224
WABW	Wooster, O.	234
WABX	Mt. Clemens, Mich.	270
WABY	Philadelphia, Pa.	242
WABZ	New Orleans, La.	263
WADC	Akron, O.	258
WAFD	Port Huron, Mich.	233
WAHG	Richmond Hill, N. Y.	315
WAMC	New York, N. Y.	340
WAMD	Minneapolis, Minn.	244
WBAA	W. Lafayette, Ind.	283
WBAC	Clemson Coll., S. C.	331
WBAH	Minneapolis, Minn.	417
WBAO	Decatur, Ill.	360
WBAP	Fort Worth, Tex.	476
WBAV	Columbus, O.	292
WBAX	Wilkes-Barre, Pa.	254
WBAY	New York, N. Y.	492
WBBG	Mattapoisett, Mass.	248
WBBL	Richmond, Va.	253
WBBM	Chicago, Ill.	226
WBBN	Wilmington, N. C.	275
WBBP	Petoskey, Mich.	246
WBBR	Rossville, N. Y.	273
WBBS	New Orleans, La.	252
WBBU	Monmouth, Ill.	224
WBBV	Johnstown, Pa.	245
WBBX	Norfolk, Va.	222
WBBY	Charleston, S. C.	268
WBBZ	Indianapolis, Ind.	227
WBCN	Chicago, Ill.	266
WBDC	Grand Rapids, Mich.	256
WBES	Tacoma Park, Md.	222
WBGA	Baltimore, Md.	254
WBOQ	Richmond Hill, N. Y.	236
WBR	Butler, Pa.	286
WBRE	Wilkes-Barre, Pa.	231
WBS	Newark, N. J.	252
WBT	Charlotte, N. C.	275
WBZ	Springfield, Mass.	333

Location	Wave-length	Call Letters
FALL RIVER, MASS.	209	WGBH
FALL RIVER, MASS.	254	WSAR
FALL RIVER, MASS.	248	WTAB
FARGO, N. D.	244	WDAY
FAYETTEVILLE, ARK.	299	KFMQ
FLINT, MICH.	250	WEAA
FLINT, MICH.	218	WTHS
FOND DU LAC, WIS.	273	KFIZ
FT. BEN HARRISON, IND.	266	WCBN
FT. BEN. HARRISON, IND.	258	WFBY
FORT DODGE, IA.	231	KFER
FORT DODGE, IA.	246	KFJY
FORT SILL, OKLA.	263	KFRM
FORT WAYNE, IND.	258	WDBV
FORT WAYNE, IND.	234	WHBJ
FORT WORTH, TEX.	221	KFQB
FORT WORTH, TEX.	246	KFRO
FORT WORTH, TEX.	476	WBAP
FRANKLINTON, LA.	234	KFLD
FREEPORT, N. Y.	244	WGBB
FREMONT, NEB.	280	WOAE
FRESNO, CAL.	243	KMJ
GALESBURG, ILL.	254	WFBZ
GALESBURG, ILL.	244	WRAM
GALVESTON, TEX.	240	KFLX
GALVESTON, TEX.	258	KFUL
GLOUCESTER CITY, N. J.	268	WRAX
GRAND FORKS, N. D.	280	KFJM
GRAND RAPIDS, MICH.	256	WBDC
GRANITEVILLE, O.	229	WJD
GREELEY, COL.	273	KFKA
GREENCASTLE, IND.	231	WLAX
GREENTOWN, IA.	254	WJAK
GREENVILLE, S. C.	236	WGBT
GREENVILLE, TEX.	242	KFPM
GROVE CITY, PA.	258	WSAJ
GUNNISON, COL.	252	KFHA
HAMILTON, O.	360	WRK
HARRISBURG, PA.	266	WABB
HARRISBURG, PA.	231	WHBG
HARTFORD, CONN.	323	WTIC
HARTINGTON, NEB.	222	KFRZ
HASTINGS, NEB.	288	KFKX
HAVERFORD, PA.	261	WABQ
HAVRE, MONT.	360	KFBB
HELENA, MONT.	248	KFCC
HELENA, MONT.	261	KFNY
HELENA, MONT.	261	KFSY
HIGHLAND PARK, N. J.	233	WEBA
HOLLYWOOD, CAL.	240	KFQZ
HOLLYWOOD, CAL.	208	KFVF
HOLLYWOOD, CAL.	252	KFWB
HOLY CITY, CAL.	253	KFQU
HONOLULU, HAWAII	360	KGU
HONOLULU, HAWAII	270	KYO
HOT SPRINGS, ARK.	375	KTHS
HOUGHTON, MICH.	266	KFMW
HOUGHTON, MICH.	244	WWOA
HOULTON, MO.	280	WCBL
HOUSTON, TEX.	248	KFVI
HOUSTON, TEX.	256	WRAA
HOUSTON, TEX.	360	WEAY
HOUSTON, TEX.	360	WSAV
INDEPENDENCE, MO.	240	KFIX
INDIANAPOLIS, IND.	227	WBBZ
IOWA CITY, IA.	284	KFQP
IOWA CITY, IA.	498	WSUI
ITHACA, N. Y.	286	WEAI
JAMESTOWN, N. Y.	275	WOCL
JEFFERSON CITY, MO.	440	WOS
JENNINGS, LA.	244	WCBJ
JOHNSTOWN, PA.	245	WBBV
JOHNSTOWN, PA.	248	WGBK
JOHNSTOWN, PA.	256	WHBP
JOHNSTOWN, PA.	360	WTAC
JOLIET, ILL.	200	WIB
JOLIET, ILL.	242	WWAE
JOPLIN, MO.	283	WHAH
JUNEAU, ALASKA	226	KFIU
KALAMAZOO, MICH.	283	WLAQ
KANSAS CITY, MO.	365	WDAF
KANSAS CITY, MO.	365	WHB
KELLOGG, IDA.	233	KFEY
KENOSHA, WIS.	225	WOAR
KINGSTON, N. Y.	233	WDBZ
KNOXVILLE, TENN.	250	WFBC
KUKAH BAY, ALASKA	263	KNT
LACONIA, N. H.	254	WKAV

Wave-length	Location	Call Letters
242	Ottumwa, Ia.	KFJL
242	Oxford, Miss.	WCBH
242	Philadelphia, Pa.	WABY
242	Salt Lake City, Utah	KFPH
242	Superior, Wis.	WEBC
242	Tecumseh, Neb.	WTAU
242	Yakima, Wash.	KFIQ
242	Yellow Springs, O.	WRAV
243	Fresno, Cal.	KMJ
244	Boston, Mass.	WTAT
244	Columbus, Ga.	WHBV
244	Fargo, N. D.	WDAY
244	Freeport, N. Y.	WGBB
244	Galesburg, Ill.	WRAM
244	Houghton, Mich.	WWOA
244	Jennings, La.	WCBJ
244	La Crosse, Wis.	WABN
244	Minneapolis, Minn.	WAMD
244	Missoula, Mont.	KUOM
244	San Diego, Cal.	KDPT
245	Canton, O.	WHBC
245	Johnstown, Pa.	WBBV
246	Anderson, Ind.	WEBD
246	Carthage, Ill.	WCAZ
246	Fort Dodge, Ia.	KFJY
246	Fort Worth, Tex.	KFRO
246	Milwaukee, Wis.	WSOE
246	Moberly, Mo.	KFOJ
246	Petoskey, Mich.	WBBP
246	Providence, R. I.	WCBR
246	San Francisco, Cal.	KUO
248	Cambridge, O.	WEBE
248	Chickasha, Okla.	KFGD
248	Cincinnati, O.	WAAD
248	Fall River, Mass.	WTAB
248	Helena, Mont.	KFCC
248	Houston, Tex.	KFVI
248	Johnstown, Pa.	WGBK
248	Lancaster, Pa.	WGAL
248	Marshalltown, Ia.	KFJB
248	Mattapoisette, Mass.	WBBG
248	Menominee, Mich.	KFLB
248	Northbend, Wash.	KFQW
248	Omaha, Neb.	KFOX
248	Portland, Ore.	KFEC
248	Portland, Ore.	KFIF
248	Sacramento, Cal.	KFVK
248	Virginia, Minn.	KFUZ
248	Yankton, S. D.	WNAX
250	Auburn, Ala.	WMAV
250	Boston, Mass.	WNAB
250	Burlington, Vt.	WCAX
250	Chicago, Ill.	WMBB
250	Conway, Ark.	KFKQ
250	Conway, Ark.	KFRJ
250	Flint, Mich.	WEAA
250	Knoxville, Tenn.	WFBC
250	Memphis, Tenn.	WCBO
250	Oil City, Pa.	WHBA
250	Salt Lake City, Utah	KDYL
250	Tacoma, Wash.	KFBG
250	Tacoma, Wash.	KMO
250	Tampa, Fla.	WGBP
250	Tulsa, Okla.	WLAL
252	Astoria, Ore.	KFJI
252	Bangor, Me.	WDBN
252	Boise, Ida.	KFDD
252	Dennison, Tex.	KFQT
252	Gunnison, Col.	KFHA
252	Hollywood, Cal.	KFWB
252	Newark, N. J.	WBS
252	New Orleans, La.	WBBS
252	Oklahoma City, Okla.	KFJF
252	Orono, Me.	WGBX
252	Shreveport, La.	WGAQ
252	Spokane, Wash.	KFIO
252	Springfield, Mo.	WFUV
252	Tacoma, Wash.	KGB
252	Toledo, O.	WTAL
252	Tullahoma, Tenn.	WCBV
253	Holy City, Cal.	KFQU
253	Lacy, Wash.	KGY
253	Richmond, Va.	WBBL
254	Albuquerque, N. M	KFLR
254	Arnold, Pa.	WCBU
254	Baltimore, Md.	WBGA
254	Baton Rouge, La.	KFGC
254	Butte, Mont.	KFUY

Call Letters	Location	Wave-length
WCAD	Canton, N. Y.	280
WCAE	Pittsburgh, Pa.	461
WCAG	New Orleans, La.	262
WCAH	Columbus, O.	286
WCAJ	University Pl., Neb.	283
WCAL	Northfield, Minn.	336
WCAO	Baltimore, Md.	275
WCAP	Washington, D. C.	468
WCAR	San Antonio, Tex.	263
WCAS	Minneapolis, Minn.	280
WCAT	Rapid City, S. D.	240
WCAU	Philadelphia, Pa.	278
WCAV	Little Rock, Ark.	263
WCAX	Burlington, Vt.	250
WCAZ	Carthage, Ill.	246
WCBA	Allentown, Pa.	280
WCBC	Ann Arbor, Mich.	280
WCBD	Zion, Ill.	344
WCBE	New Orleans, La.	263
WCBF	Pittsburgh, Pa.	236
WCBG	Pascagoula, Miss.	268
WCBH	Oxford, Miss.	242
WCBI	Bemis, Tenn.	240
WCBJ	Jennings, La.	244
WCBL	Houlton, Mo.	280
WCBM	Baltimore, Md.	229
WCBN	Ft. Ben. Harrison, Ind.	266
WCBO	Memphis, Tenn.	250
WCBQ	Nashville, Tenn.	236
WCBR	Providence, R. I.	246
WCBT	Worcester, Mass.	238
WCBU	Arnold, Pa.	254
WCBV	Tullahoma, Tenn.	252
WCBW	Macon, Ga.	226
WCBX	Newark, N. J.	233
WCBY	Buck Hill Falls, Pa.	268
WCCO	Twin Cities, Minn.	416
WCEE	Elgin, Ill.	278
WCK	St. Louis, Mo.	275
WCX	Detroit, Mich.	516
WDAE	Tampa, Fla.	365
WDAF	Kansas City, Mo.	365
WDAG	Amarillo, Tex.	263
WDAH	El Paso, Tex.	268
WDAR	Philadelphia, Pa.	394
WDAY	Fargo, N. D.	244
WDBA	Columbus, Ga.	236
WDBB	Taunton, Mass.	229
WDBC	Lancaster, Pa.	258
WDBE	Atlanta, Ga.	278
WDBF	Youngstown, O.	315
WDBH	Worcester, Mass.	268
WDBI	St. Petersburg, Fla.	226
WDBJ	Roanoke, Va.	229
WDBK	Cleveland, O.	227
WDBL	Stevens Point, Wis.	278
WDBN	Bangor, Me.	252
WDBO	Winter Park, Fla.	240
WDBP	Superior, Wis.	261
WDBQ	Salem, N. J.	234
WDBR	Boston, Mass.	256
WDBS	Dayton, O.	283
WDBV	Fort Wayne, Ind.	258
WDBW	Columbia, Tenn.	268
WDBX	New York, N. Y.	233
WDBY	Chicago, Ill.	258
WDBZ	Kingston, N. Y.	233
WDM	Washington, D. C.	234
WDOB	Chattanooga, Tenn.	256
WDWF	Cranston, R. I.	440
WDZ	Tuscola, Ill.	278
WEAA	Flint, Mich.	250
WEAF	New York, N. Y.	485
WEAH	Wichita, Kan.	280
WEAI	Ithaca, N. Y.	286
WEAJ	Vermilion, S. D.	283
WEAM	North Plainfield, N. J.	286
WEAN	Providence, R. I.	273
WEAO	Columbus, O.	293
WEAR	Cleveland, O.	389
WEAU	Sioux City, Ia.	275
WEAY	Houston, Tex.	360
WEB	St. Louis, Mo.	273
WEBA	Highland Park, N. J.	233
WEBC	Superior, Wis.	242
WEBD	Anderson, Ind.	246
WEBE	Cambridge, O.	248
WEBH	Chicago, Ill.	370

Location	Wave-length	Call Letters
LA CROSSE, WIS.	244	WABN
LACY, WASH.	253	KGY
LAKE FOREST, ILL.	227	WABA
LAMBERTVILLE, N. J.	283	WTAZ
LAMONI, IA.	280	KFFV
LANCASTER, PA.	258	WDBC
LANCASTER, PA.	248	WGAL
LANSING, MICH.	286	WREO
LAPORTE, IND.	224	WRAF
LARAMIE, WYO.	283	KFBU
LA SALLE, ILL.	266	WGBN
LA SALLE, ILL.	234	WJBC
LAWRENCE, KAN.	275	KFKU
LAWRENCEBURG, TENN.	280	WOAN
LIMA, O.	260	WOAC
LINCOLN, NEB.	275	WFAV
LINCOLN, NEB.	229	WJAB
LINCOLN, NEB.	254	WMAH
LITTLE ROCK, ARK.	254	KFMB
LITTLE ROCK, ARK.	263	WCAV
LOCKPORT, N. Y.	273	WMAK
LOGANSPORT, IND.	220	WHBL
LONG BEACH, CAL.	234	KFON
LOS ANGELES, CAL.	468	KFI
LOS ANGELES, CAL.	238	KFPG
LOS ANGELES, CAL.	231	KFPR
LOS ANGELES, CAL.	226	KFQG
LOS ANGELES, CAL.	272	KFSG
LOS ANGELES, CAL.	405	KHJ
LOS ANGELES, CAL.	293	KJS
LOS ANGELES, CAL.	337	KNX
LOS ANGELES, CAL.	360	KWH
LOUISVILLE, KY.	399	WHAS
LOUISVILLE, KY.	286	WLAP
LOWELL, MASS.	266	WQAS
MACON, GA.	226	WCBW
MACON, GA.	261	WMAZ
MADISON, WIS.	535	WHA
MADISON, WIS.	236	WIBA
MANHATTAN, KAN.	218	KFVH
MANHATTAN, KAN.	341	KSAC
MANHATTAN, KAN.	273	WTG
MARENGO, IA.	234	KFOL
MARION, IND.	226	WIAQ
MARSHALLTOWN, IA.	248	KFJB
MARSHFIELD, ORE.	240	KFOP
MARSHFIELD, WIS.	229	WGBR
MARTINSBURG, W. VA.	209	WIBE
MATTAPOISETT, MASS.	248	WBBG
MECHANICSBURG, O.	208	WHBS
McKEESPORT, PA.	234	WIK
MEDFORD HILLSIDE, MASS.	261	WGI
MEMPHIS, TENN.	250	WCBO
MEMPHIS, TENN.	266	WGBC
MEMPHIS, TENN.	233	WHBQ
MEMPHIS, TENN.	503	WMC
MENOMINEE, MICH.	248	KFLB
MENOMINEE, WIS.	234	WGBQ
MIAMI, FLA.	283	WQAM
MIAMI BEACH, FLA.	384	WMBF
MILFORD, KAN.	286	KFKB
MILWAUKEE, WIS.	280	WHAD
MILWAUKEE, WIS.	246	WSOE
MINNEAPOLIS, MINN.	231	KFDZ
MINNEAPOLIS, MINN.	261	KFEK
MINNEAPOLIS, MINN.	231	KFMT
MINNEAPOLIS, MINN.	244	WAMD
MINNEAPOLIS, MINN.	417	WBAH
MINNEAPOLIS, MINN.	280	WCAS
MINNEAPOLIS, MINN.	417	WLAG
MINNEAPOLIS, MINN.	278	WLB
MISHAWAKA, IND.	369	WOAO
MISSOULA, MONT.	244	KUOM
MOBERLY, MO.	266	KFFP
MOBERLY, MO.	246	KFOJ
MONMOUTH, ILL.	224	WBBU
MONTGOMERY, ALA.	226	WKAN
MOOREHEAD, MINN.	286	WPAU
MOOSEHEART, ILL.	303	WJJD
MOSCOW, IDA.	230	KFAN
MT. CLEMENT, MICH.	270	WABX
NASHVILLE, TENN.	236	WCBQ
NASHVILLE, TENN.	263	WEBX
NEAH BAY, WASH.	261	KFHH
NEW BEDFORD, MASS.	209	WIBH
NEW HAVEN, CONN.	268	WPAJ
NEW ORLEANS, LA.	263	WAAB
NEW ORLEANS, LA.	275	WAAC

Wave-length	Location	Call Letters
254	Coldwater, Miss.	KFNG
254	Columbia, Mo.	WAAN
254	Corvallis, Ore.	KFDJ
254	Denver, Col.	KFEL
254	Fall River, Mass.	WSAR
254	Galesburg, Ill.	WFBZ
254	Greentown, Ia.	WJAK
254	Laconia, N. H.	WKAV
254	Lincoln, Neb.	WMAH
254	Little Rock, Ark.	KFMB
254	Philadelphia, Pa.	WIAD
254	Philadelphia, Pa.	WNAT
254	Richmond, Cal.	KFOU
254	Saginaw, Mich.	WABM
254	Wilkes-Barre, Pa.	WBAX
255	Omaha, Neb.	WNAL
255	Raleigh, N. C.	WFBQ
256	Boston, Mass.	WDBR
256	Cedar Rapids, Ia.	KFLP
256	Chattanooga, Tenn.	WDOD
256	Escanaba, Mich.	WRAK
256	Grand Rapids, Mich.	WBDC
256	Houston, Tex.	WRAA
256	Johnstown, Pa.	WHBP
256	Trenton, N. J.	WMAL
256	Walla Walla, Wash.	KFCF
256	Washington, D. C.	WRHF
258	Akron, O.	WADC
258	Chicago, Ill.	WDBY
258	Ft. Ben. Harrison, Ind.	WFBY
258	Fort Wayne, Ind.	WDBV
258	Galveston, Tex.	KFUL
258	Grove City, Pa.	WSAJ
258	Lancaster, Pa.	WDBC
258	Norman, Okla.	WNAD
258	Omaha, Neb.	KFCZ
258	Pomeroy, O.	WSAZ
258	Rochester, N. Y.	WHEC
258	St. Petersburg, Fla.	WHBN
258	Stevensville, Mont.	KFJR
258	Taft, Cal.	KFQC
260	Lima, O.	WOAC
260	New Orleans, La.	WWL
260	Washington, D. C.	WMU
261	Altoona, Pa.	WFBG
261	Casenovia, N. Y.	WMAC
261	Dallas, Tex.	WRR
261	Haverford, Pa.	WABQ
261	Helena, Mont.	KFNY
261	Helena, Mont.	KFSY
261	Macon, Ga.	WMAZ
261	Medford Hillside, Mass.	WGI
261	Minneapolis, Minn.	KFEK
261	Neah Bay, Wash	KFHH
261	Providence, R. I.	WSAD
261	Salt Lake City, Utah	KFOO
261	Sioux City, Ia.	KFMR
261	Superior, Wis.	WDBP
262	New Orleans, La.	WCAG
263	Amarillo, Tex.	WDAG
263	Fort Sill, Okla.	KFRM
263	Kukah Bay, Alaska	KNT
263	Little Rock, Ark.	WCAV
263	Nashville, Tenn.	WEBX
263	Newark, N. J.	WAAM
263	New Orleans, La.	WAAB
263	New Orleans, La.	WABZ
263	New Orleans, La.	WCBE
263	New York, N. Y.	WSAP
263	San Antonio, Tex.	WCAR
263	St. Louis, Mo.	WRAO
264	St. Louis, Mo.	KFQA
264	St. Petersburg, Fla.	WSAG
266	Chicago, Ill.	WBCN
266	Chicago, Ill.	WENR
266	Ft. Ben. Harrison, Ind.	WCBN
266	Harrisburg, Pa.	WABB
266	Houghton, Mich.	KFMW
266	La Salle, Ill.	WGBN
266	Lowell, Mass.	WQAS
266	Memphis, Tenn.	WGBC
266	Moberly, Mo.	WFEP
266	Shenandoah, Ia.	KFNF
266	State College, N. M.	KFRY
268	Buck Hill Falls, Pa.	WCBY
268	Cartersville, Mo.	KFPW
268	Cedar Rapids, Ia.	WJAM
268	Charleston, S. C.	WBBY

Call Letters	*Location*	*Wave-length*
WEBJ	New York, N. Y.	273
WEBM	A Portable	226
WEBP	New Orleans, La.	280
WEBT	Dayton, O.	270
WEBW	Beloit, Wis.	283
WEBX	Nashville, Tenn.	263
WEEI	Boston, Mass.	475
WEMC	Berrien Springs, Mich.	285
WENR	Chicago, Ill.	266
WEW	St. Louis, Mo.	280
WFAA	Dallas, Tex.	472
WFAM	St. Cloud, Minn.	273
WFAV	Lincoln, Neb.	275
WFBB	Eureka, Ill.	240
WFBC	Knoxville, Tenn.	250
WFBD	Philadelphia, Pa.	234
WFBE	Seymour, Ind.	226
WFBG	Altoona, Pa.	261
WFBH	New York, N Y.	273
WFBJ	Collegeville, Minn.	236
WFBQ	Raleigh, N. C.	255
WFBR	Baltimore, Md.	452
WFBW	Cincinnati, O.	309
WFBY	Ft. Ben Harrison, Ind.	258
WFBZ	Galesburg, Ill.	254
WFI	Philadelphia, Pa.	394
WFKB	Chicago, Ill.	217
WFUV	Springfield, Mo.	252
WGAL	Lancaster, Pa.	248
WGAQ	Shreveport, La.	252
WGAZ	South Bend, Ind.	360
WGBB	Freeport, N. Y.	244
WGBC	Memphis, Tenn.	266
WGBF	Evansville, Ind.	217
WGBG	Thrifton, Va.	226
WGBH	Fall River, Mass.	209
WGBI	Scranton, Pa.	240
WGBK	Johnstown, Pa.	248
WGBM	Providence, R. I.	234
WGBN	LaSalle, Ill.	266
WGBO	San Juan, P. R.	275
WGBP	Tampa, Fla.	250
WGBL	Elyria, O.	227
WGBQ	Menominee, Wis.	234
WGBR	Marshfield, Wis.	229
WGBS	New York, N. Y.	315
WGBT	Greenville, S. C.	236
WGBW	Spring Valley, Ill.	212
WGBX	Orono, Me.	252
WGBY	R. R. No. 2	218
WGI	Medford Hillside, Mass.	261
WGN	Chicago, Ill.	370
WGR	Buffalo, N. Y.	319
WGY	Schenectady, N. Y.	379
WHA	Madison, Wis.	535
WHAD	Milwaukee, Wis.	280
WHAG	Cincinnati, O.	222
WHAH	Joplin, Mo.	283
WHAM	Rochester, N. Y.	278
WHAP	Brooklyn, N. Y.	240
WHAR	Atlantic City, N. J.	275
WHAS	Louisville, Ky.	399
WHAV	Wilmington, Del.	360
WHAZ	Troy, N. Y.	385
WHB	Kansas City, Mo.	365
WHBA	Oil City, Pa.	250
WHBB	Stevens Point, Wis.	240
WHBC	Canton, O.	245
WHBD	Bellefontaine, O.	222
WHBF	Rock Island, Ill.	222
WHBG	Harrisburg, Pa.	231
WHBH	Culver, Ind.	222
WHBI	Chesaning, Mich.	227
WHBJ	Fort Wayne, Ind.	234
WHBK	Ellsworth, Me.	231
WHBL	Logansport, Ind.	220
WHBM	Chicago, Ill.	233
WHBN	St. Petersburg, Fla.	258
WHBO	Pawtucket, R. I.	231
WHBP	Johnstown, Pa.	256
WHBQ	Memphis, Tenn.	233
WHBR	Cincinnati, O.	216
WHBS	Mechanicsburg, O.	208
WHBT	Downers Grove, Ill.	206
WHBU	Anderson, Ind.	218
WHBV	Columbus, Ga.	244
WHBW	Philadelphia, Pa.	215
WHBX	Punxsutawny, Pa.	212

Location	*Wave-length*	*Call Letters*
NEW ORLEANS, LA.	263	WABZ
NEW ORLEANS, LA.	252	WBBS
NEW ORLEANS, LA.	262	WCAG
NEW ORLEANS, LA.	263	WCBE
NEW ORLEANS, LA.	280	WEBP
NEW ORLEANS, LA.	270	WOWL
NEW ORLEANS, LA.	319	WSMB
NEW ORLEANS, LA.	260	WWL
NEWARK, N. J.	263	WAAM
NEWARK, N.J.	252	WBS
NEWARK, N. J.	233	WCBX
NEWARK, N. J.	405	WOR
NEW YORK, N. Y.	340	WAMC
NEW YORK, N. Y.	492	WBAY
NEW YORK, N. Y.	233	WDBX
NEW YORK, N. Y.	485	WEAF
NEW YORK, N. Y.	273	WEBJ
NEW YORK, N. Y.	273	WFBH
NEW YORK, N. Y.	315	WGBS
NEW YORK, N. Y.	360	WHN
NEW YORK, N. Y.	455	WJY
NEW YORK, N. Y.	455	WJZ
NEW YORK, N. Y.	526	WNYC
NEW YORK, N. Y.	360	WQAO
NEW YORK, N. Y.	263	WSAP
NORFOLK, NEB.	283	WJAG
NORFOLK, VA.	222	WBBX
NORFOLK, VA.	280	WTAR
NORMA, OKLA.	258	WNAD
NORTH BEND, WASH.	248	KFQW
NORTHFIELD, MINN.	336	KFMX
NORTHFIELD, MINN.	336	WCAL
N. PLAINFIELD, N. J.	286	WEAM
OAK, NEB.	268	KFEQ
OAKLAND, CAL.	233	KFUS
OAKLAND, CAL.	361	KGO
OAKLAND, CAL.	242	KLS
OAKLAND, CAL.	508	KLX
OAKLAND, CAL.	360	KZM
OAK PARK, ILL.	283	WTAY
OGDEN, UTAH	360	KFCP
OGDEN, UTAH	224	KFUR
OGDEN, UTAH	214	KFWA
OIL CITY, PA.	250	WHBA
OKLAHOMA CITY, OKLA.	252	KFJF
OKLAHOMA CITY, OKLA.	220	KFQR
OKLAHOMA CITY, OKLA.	275	WKY
OKMULGEE, OKLA.	360	WPAC
OLYMPIA, WASH.	220	KFRW
OMAHA, NEB.	258	KFCZ
OMAHA, NEB.	248	KFOX
OMAHA, NEB.	285	WAAW
OMAHA, NEB.	273	WIAK
OMAHA, NEB.	255	WNAL
OMAHA, NEB.	526	WOAW
ORONO, ME.	252	WGBX
OSKALOOSA, IA.	240	KFHL
OSSEO, WIS.	220	WTAQ
OTTUMA, IA.	242	KFJL
OWOSSO, MICH.	240	WSMH
OXFORD, MISS.	242	WCBH
PASADENA, CAL.	229	KPPC
PASCAGOULA, MISS.	268	WCBG
PASO ROBLES, CAL.	240	KFNL
PARKERSBURG, PA.	270	WQAA
PAWTUCKET, R. I.	231	WHBO
PEORIA, ILL.	280	WJAN
PETOSKEY, MICH.	246	WBBP
PHILADELPHIA, PA.	242	WABY
PHILADELPHIA, PA.	278	WCAU
PHILADELPHIA, PA.	394	WDAR
PHILADELPHIA, PA.	234	WFBD
PHILADELPHIA, PA.	394	WFI
PHILADELPHIA, PA.	215	WHBW
PHILADELPHIA, PA.	254	WIAD
PHILADELPHIA, PA.	509	WIP
PHILADELPHIA, PA.	254	WNAT
PHILADELPHIA, PA.	509	WOO
PHILADELPHIA, PA.	360	WWAD
PHOENIX, ARIZ.	360	KFAD
PHOENIX, ARIZ.	238	KFCB
PITTSBURGH, PA.	270	KQV
PITTSBURGH, PA.	461	WCAE
PITTSBURGH, PA.	236	WCBF
PITTSBURGH, PA.	286	WJAS
POMEROY, O.	258	WSAZ
A PORTABLE	226	WEBM
PORT CHESTER, N. Y.	233	WSAY

Wave-length	*Location*	*Call Letters*
268	Chicago, Ill.	WJAZ
268	Chicago, Ill.	WTX
268	Columbia, Tenn.	WDBW
268	Denver, Col.	KFLE
268	El Paso, Tex.	WDAH
268	Gloucester City, N. J.	WRAX
268	New Haven, Conn.	WPAJ
268	Oak, Neb.	KFEQ
268	Pascagoula, Miss.	WCBG
268	Salt Lake City, Utah	KFPT
268	Worcester, Mass.	WDBH
270	Cleveland, O.	KDPM
270	Dayton, O.	WEBT
270	Honolulu, Hawaii	KYO
270	Mt. Clemens, Mich.	WABX
270	New Orleans, La.	WOWL
270	Parkersburg, Va.	WQAA
270	Pittsburgh, Pa.	KQV
270	Schenectady, N. Y.	WRL
270	Seattle, Wash.	WDZE
270	Toledo, O.	WABR
271	Boise, Ida.	KFAU
271	Salt Lake City, Utah	KFUT
271	Springfield, O.	WNAP
272	Los Angeles, Cal.	KFSG
273	Atlantic, Ia.	KFLZ
273	Belden, Neb.	KFQY
273	Charlestown, W. Va.	WPAZ
273	Cleveland, O.	WHK
273	Dearborn, Mich.	WWI
273	Fond du Lac, Wis.	KFIZ
273	Greeley, Col.	KFKA
273	Lockport, N. Y.	WMAK
273	Manhattan, Kan.	WTG
273	New York, N. Y.	WEBJ
273	New York, N. Y.	WFBH
273	Omaha, Neb.	WIAK
273	Providence, R. I.	WEAN
273	Rossville, N. Y.	WBBR
273	Seattle, Wash.	KHQ
273	Stanford U., Cal.	KFGH
273	St. Cloud, Minn.	WFAM
273	St. Louis, Mo.	WEB
273	Tarrytown, N. Y.	WRW
273	Urbana, Ill.	WRM
273	Utica, N. Y.	WSL
274	Belvidere, Ill.	WOAG
275	Atlantic City, N. J.	WHAR
275	Baltimore, Md.	WCAO
275	Batavia, Ill.	WORD
275	Berkeley, Cal.	KRE
275	Cape Girardeau, Mo.	WSAB
275	Charlotte, N. C.	WBT
275	Jamestown, N. Y.	WOCL
275	Lawrence, Kan.	KFKU
275	Lincoln, Neb.	WFAV
275	New Orleans, La.	WAAC
275	Oklahoma City, Okla.	WKY
275	San Juan, P. R.	WGBO
275	Sioux City, Ia.	WEAU
275	Springfield, Vt.	WQAE
275	St. Louis, Mo.	WCK
275	Wilmington, N. C.	WBBN
278	Atlanta, Ga.	WDBE
278	Cedar Rapids, Ia.	WKAA
278	Denver, Col.	KFAF
278	Elgin, Ill.	WCEE
278	Minneapolis, Minn.	WLB
278	Philadelphia, Pa.	WCAU
278	Rochester, N. Y.	WHAM
278	San Diego, Cal.	KFBC
278	Stevens Point, Wis.	WDBL
278	Stevens Point, Wis.	WLBL
278	Tuscola, Ill.	WDZ
278	Valparaiso, Ind.	WRBC
280	Allentown, Pa.	WCBA
280	Ann Arbor, Mich.	WCBC
280	Canton, N. Y.	WCAD
280	Cedar Falls, Ia.	KFJX
280	College Station, Tex.	WTAW
280	Fremont, Neb.	WOAE
280	Grand Forks, N. D.	KFJM
280	Houlton, Mo.	WCBL
280	Lawrenceburg, Tenn.	WOAN
280	Lamoni, Ia.	KFFV
280	Milwaukee, Wis.	WHAD
280	Minneapolis, Minn.	WCAS
280	New Orleans, La.	WEBP

Call Letters	Location	Wave-length
WHEC	Rochester, N. Y.	258
WHK	Cleveland, O.	273
WHN	New York, N. Y.	360
WHO	Des Moines, Ia.	526
WHT	Deerfield, Ill.	238
WIAD	Philadelphia, Pa.	254
WIAK	Omaha, Neb.	273
WIAQ	Marion, Ind.	226
WIAS	Burlington, Ia.	283
WIBA	Madison, Wis.	236
WIBC	St. Petersburg, Fla.	222
WIBD	Joliet, Ill.	200
WIBE	Martinsburg, W. Va.	209
WIBF	Wheatland, Wis.	231
WIBG	Elkins Park, Pa.	222
WIBH	New Bedford, Mass.	209
WIBO	Chicago, Ill.	226
WIK	McKeesport, Pa.	234
WIL	Washington, D. C.	360
WIP	Philadelphia, Pa.	509
WJAB	Lincoln, Neb.	229
WJAD	Waco Tex.	352
WJAG	Norfolk, Neb.	283
WJAK	Greentown, Ia.	254
WJAM	Cedar Rapids, Ia.	268
WJAN	Peoria, Ill.	280
WJAR	Providence, R. I.	305
WJAS	Pittsburgh, Pa.	286
WJBC	La Salle, Ill.	234
WJAZ	Chicago, Ill.	268
WJBD	Ashland, Wis.	233
WJD	Graniteville, O.	229
WJJD	Mooseheart, Ill.	303
WJY	New York, N. Y.	455
WJZ	New York, N. Y.	455
WKAA	Cedar Rapids, Ia.	278
WKAD	East Providence, R. I.	240
WKAN	Montgomery, Ala.	226
WKAP	Cranston, R. I.	234
WKAQ	San Juan, P. R.	340
WKAR	East Lansing, Mich.	285
WKAV	Laconia, N. H.	254
WKBE	Webster, Mass.	231
WKBF	Cranston, R. I.	286
WKY	Oklahoma City, Okla.	275
WLAG	Minneapolis, Minn.	417
WLAL	Tulsa, Okla.	250
WLAP	Louisville, Ky.	286
WLAQ	Kalamazoo, Mich.	283
WLAX	Greencastle, Ind.	231
WLB	Minneapolis, Minn.	278
WLBL	Stevens Point, Wis.	278
WLS	Chicago, Ill.	344
WLW	Cincinnati, O.	422
WMAC	Cazenovia, N. Y.	261
WMAF	Dartmouth, Mass.	360
WMAH	Lincoln, Neb.	254
WMAK	Lockport, N. Y.	273
WMAL	Trenton, N. J.	256
WMAN	Columbus, O.	286
WMAQ	Chicago, Ill.	447
WMAV	Auburn, Ala.	250
WMAY	St. Louis, Mo.	280
WMAZ	Macon, Ga.	261
WMBB	Chicago, Ill.	250
WMBF	Miami Beach, Fla.	384
WMC	Memphis, Tenn.	503
WMH	Cincinnati, O.	321
WMU	Washington, D. C.	260
WNAB	Boston, Mass.	250
WNAC	Boston, Mass.	284
WNAD	Norman, Okla.	258
WNAL	Omaha, Neb.	255
WNAP	Springfield, O.	271
WNAR	Butler, Mo.	230
WNAT	Philadelphia, Pa.	254
WNAX	Yankton, S. D.	248
WNYC	New York, N. Y.	526
WOAC	Lima, O.	260
WOAE	Fremont, Neb.	280
WOAG	Belvidere, Ill.	274
WOAI	San Antonio, Tex.	392
WOAN	Lawrenceburg, Tenn.	280
WOAO	Mishawaka, Ind.	369
WOAR	Kenosha, Wis.	225
WOAT	Wilmington, Del.	360
WOAV	Erie, Pa.	242
WOAW	Omaha, Neb.	526

Location	Wave-length	Call Letters
PORT HURON, MICH.	233	WAFD
PORTLAND, ORE.	248	KFIF
PORTLAND, ORE.	248	KFEC
PORTLAND, ORE.	283	KFQN
PORTLAND, ORE.	491	KGW
PROVIDENCE, R. I.	246	WCBR
PROVIDENCE, R. I.	273	WEAN
PROVIDENCE, R. I.	234	WGBM
PROVIDENCE, R. I.	305	WJAR
PROVIDENCE, R. I.	261	WSAD
PULLMAN, WASH.	348	KFAE
PULLMAN, WASH.	217	KFRX
PUNXSUTAWNY, PA.	212	WHBX
RALEIGH, N. C.	255	WFBQ
RAPID CITY, S. D.	240	WCAT
READING, PA.	238	WRAW
RICHMOND, CAL.	254	KFOU
RICHMOND, VA	253	WBBL
RICHMOND HILL, N. Y.	315	WAHG
RICHMOND HILL, N. Y.	236	WBOQ
ROANOKE, VA.	229	WDBJ
ROCHESTER, N. Y.	278	WHAM
ROCHESTER, N. Y.	283	WABO
ROCHESTER, N. Y.	258	WHEC
ROCKFORD, ILL.	229	KFLV
ROCK ISLAND, ILL.	222	WHBF
ROSSVILLE, N. Y.	273	WBBR
R. R. NO. 2	218	WGBY
SACRAMENTO, CAL.	283	KFBK
SACRAMENTO, CAL.	248	KFVK
SANDUSKY, O.	240	WABH
SAGINAW, MICH.	254	WABM
SALEM, N. J.	234	WDBQ
SALT LAKE CITY, UTAH	250	KDYL
SALT LAKE CITY, UTAH	261	KFOO
SALT LAKE CITY, UTAH	242	KFPH
SALT LAKE CITY, UTAH	268	KFPT
SALT LAKE CITY, UTAH	271	KFUT
SALT LAKE CITY, UTAH	299	KSL
SAN ANTONIO, TEX.	263	WCAR
SAN ANTONIO, TEX.	392	WOAI
SAN BENITO, TEX.	236	KFLU
SAN DIEGO, CAL.	244	KDPT
SAN DIEGO, CAL.	280	KDYM
SAN DIEGO, CAL.	278	KFBC
SAN FRANCISCO, CAL.	236	KFPV
SAN FRANCISCO, CAL.	234	KFUQ
SAN FRANCISCO, CAL.	428	KPO
SAN FRANCISCO, CAL.	246	KUO
SAN JOSE, CAL.	226	KFVJ
SAN JOSE, CAL.	240	KQW
SAN JUAN, P. R.	275	WGBO
SAN JUAN, P. R.	340	WKAQ
SAN LEANDRO, CAL.	234	KFUU
SAN LUIS OBISPO, CAL.	218	KFBE
SAN PEDRO, CAL.	205	KFVD
SANTA ANA, CAL.	280	KFAW
SANTA ROSA, CAL.	234	KFNV
SCHENECTADY, N. Y.	379	WGY
SCHENECTADY, N. Y.	270	WRL
SCRANTON, PA.	240	WGBI
SCRANTON, PA.	280	WQAN
SEATTLE, WASH.	270	KDZE
SEATTLE, WASH.	283	KFHR
SEATTLE, WASH.	384	KFOA
SEATTLE, WASH.	224	KFPB
SEATTLE, WASH.	233	KFQX
SEATTLE, WASH.	273	KHQ
SEATTLE, WASH.	384	KJR
SEATTLE, WASH.	454	KTW
SEYMOUR, IND.	226	WFBE
SHENANDOAH, IA.	266	KFNF
SHREVEPORT, LA.	360	KFDX
SHREVEPORT, LA.	252	WGAQ
SIOUX CITY, IA.	275	WEAU
SIOUX CITY, IA.	261	KFMR
SORRS, CONN.	283	WABL
SOUTH BEND, IND.	360	WGAZ
SPOKANE, WASH.	252	KFIO
SPOKANE, WASH.	283	KFPY
SPRINGFIELD, MASS.	333	WBZ
SPRINGFIELD, MO.	252	WFUV
SPRINGFIELD, O.	271	WNAP
SPRINGFIELD, VT.	275	WQAE
SPRING VALLEY, ILL.	212	WGBW
ST. CLOUD, MINN.	273	WFAM
ST. LOUIS, MO.	264	KFQA
ST. LOUIS, MO.	549	KFUO

Wave-length	Location	Call Letters
280	Norfolk, Va.	WTAR
280	Peoria, Ill.	WJAN
280	San Diego, Cal.	KDYM
280	Santa Ana, Cal.	KFAW
280	Scranton, Pa.	WQAN
280	St. Louis, Mo.	WEW
280	St. Louis, Mo.	WMAY
280	Wichita, Kan.	WEAH
283	Agricultural Col., N. D.	WPAK
283	Beloit, Wis.	WEBW
283	Burlington, Ia.	WIAS
283	Butte, Mont.	KFKV
283	Butte, Mont.	KFLA
283	Dayton, O.	WDBS
283	Denver, Col.	KLZ
283	Joplin, Mo.	WHAH
283	Kalamazoo, Mich	WLAQ
283	Lambertville, N. J.	WTAZ
283	Laramie, Wyo.	KFBU
283	Miami, Fla.	WQAM
283	Norfolk, Neb.	WJAG
283	Oak Park, Ill.	WTAY
283	Portland, Ore.	KFQN
283	Rochester, N. Y.	WABO
283	Sacramento, Cal.	KFBK
283	Seattle, Wash.	KFHR
283	Sorrs, Conn.	WABL
283	Spokane, Wash.	KFPY
283	State College, Pa.	WPAB
283	University Pl., Neb.	WCAJ
283	Vermilion, S. D.	WEAJ
283	West Lafayette, Ind.	WBAA
284	Boston, Mass.	WNAC
284	Iowa City, Ia.	KFQP
285	Berrien Springs, Mich.	WEMC
285	East Lansing, Mich.	WKAR
285	Omaha, Neb.	WAAW
286	Butler, Pa.	WBR
286	Chicago, Ill.	WAAF
286	Columbus, O.	WCAH
286	Columbus, O.	WMAN
286	Columbus, O.	WPAL
286	Cranston, R. I.	WKBF
286	Detroit, Mich.	KOP
286	Ithaca, N. Y.	WEAI
286	Lansing, Mich.	WREO
286	Louisville, Ky.	WLAP
286	Milford, Kan.	KFKB
286	Moorehead, Minn.	WPAU
286	North Plainfield, N. J.	WEAM
286	Pittsburgh, Pa.	WJAS
288	Hastings, Neb.	KFKX
292	Columbus, O.	WBAV
293	Columbus, O.	WEAO
293	Los Angeles, Cal.	KJS
299	Fayetteville, Ark.	KFMQ
299	Salt Lake City, Utah	KSL
300	Atlantic City, N. J.	WPG
303	Elgin, Ill.	WTAS
303	Mooseheart, Ill.	WJJD
305	Providence, R. I.	WJAR
309	Cincinnati, O.	WFBW
309	East Pittsburgh, Pa.	KDKA
315	Beaumont, Tex.	KFIM
315	New York, N. Y.	WGBS
315	Richmond, Hill, N. Y.	WAHG
315	Youngstown, O.	WDBF
319	Buffalo, N. Y.	WGR
319	New Orleans, La.	WSMB
321	Cincinnati, O.	WMH
323	Denver, Col.	KOA
323	Hartford, Conn.	WTIC
325	Cincinnati, O.	WSAI
331	Clemson College, S. C.	WBAC
333	Springfield, Mass.	WBZ
336	Clemson College, S. C.	WSAC
336	Northfield, Minn.	KFMX
336	Northfield, Minn.	WCAL
337	Los Angeles, Cal.	KNX
340	New York, N. Y.	WAMC
340	San Juan, P. R.	WKAQ
341	Manhattan, Kan.	KSAC
344	Chicago, Ill.	WLS
344	Zion, Ill.	WCBD
348	Pullman, Wash	KFAE
348	State College, N. M.	KOB
352	Detroit, Mich.	WWJ
352	Waco, Tex	WJAD

Call Letters	*Location*	*Wave-length*
WOAX	Trenton, N. J.	240
WOC	Davenport, Ia.	484
WOCL	Jamestown, N. Y.	275
WOI	Ames, Ia.	207
WOO	Philadelphia, Pa.	509
WOR	Newark, N. J.	405
WORD	Batavie Ill.	275
WOS	Jefferson City, Mo.	440
WOWL	New Orleans, La.	270
WPAB	State College, Pa.	283
WPAC	Okmulgee, Okla.	360
WPAJ	New Haven, Conn.	268
WPAK	Agricultural Col., N. D.	283
WPAL	Columbus, O.	286
WPAU	Moorehead, Minn.	286
WPAZ	Charleston, W. Va.	273
WPG	Atlantic City, N. J.	300
WQAA	Parkersburg, Pa.	270
WQAC	Amarillo, Tex.	234
WQAE	Springfield, Vt.	275
WQAM	Miami, Fla.	283
WQAN	Scranton, Pa.	280
WQAO	New York, N. Y.	360
WQAS	Lowell, Mass.	266
WQJ	Chicago, Ill.	447
WRAA	Houston, Tex.	256
WRAF	Laporte, Ind.	224
WRAK	Escanaba, Mich.	256
WRAM	Galesburg, Ill.	244
WRAN	Waterloo, Ia.	236
WRAO	St. Louis, Mo.	263
WRAV	Yellow Springs, O.	242
WRAW	Reading, Pa.	238
WRAX	Gloucester City, N. J.	268
WRBC	Valparaiso, Ind.	278
WRC	Washington, D. C.	468
WREO	Lansing, Mich.	286
WRHF	Washington, D. C.	256
WRK	Hamilton, O.	360
WRL	Schenectady, N. Y.	270
WRM	Urbana, Ill.	273
WRR	Dallas, Tex.	261
WRW	Tarrytown, N. Y.	273
WSAB	Cape Girardeau, Mo.	275
WSAC	Clemson College, S. C.	336
WSAD	Providence, R. I.	261
WSAG	St. Petersburg, Fla.	264
WSAI	Cincinnati, O.	325
WSAJ	Grove City, Pa.	258
WSAN	Allentown, Pa.	229
WSAP	New York, N. Y.	263
WSAR	Fall River, Mass.	254
WSAV	Houston, Tex.	360
WSAY	Port Chester, N. Y.	233
WSAZ	Pomeroy, O.	258
WSB	Atlanta, Ga.	428
WSL	Utica, N. Y.	273
WSMB	New Orleans, La.	319
WSMH	Owosso, Mich.	240
WSOE	Milwaukee, Wis.	246
WSRF	Broadlands, Ill.	233
WSUI	Iowa City, Ia.	498
WTAB	Fall River, Mass.	248
WTAC	Johnstown, Pa.	360
WTAL	Toledo, O.	252
WTAM	Cleveland, O.	389
WTAP	Cambridge, Ill	242
WTAQ	Osseo, Wis.	220
WTAR	Norfolk, Va.	280
WTAS	Elgin, Ill.	303
WTAT	Boston, Portable	244
WTAU	Tecumseh, Neb.	242
WTAW	College Station, Tex.	280
WTAX	Streator, Ill.	231
WTAY	Oak Park, Ill.	283
WTAZ	Lambertville, N. J.	283
WTHS	Flint, Mich.	218
WTG	Manhattan, Kan.	273
WTIC	Hartford, Conn.	323
WTX	Chicago, Ill.	268
WWAD	Philadelphia, Pa.	360
WWAE	Joliet, Ill.	242
WWI	Dearborn, Mich.	273
WWJ	Detroit, Mich.	352
WWL	New Orleans, La.	260
WWOA	Houghton, Mich.	244

Location	*Wave-length*	*Call Letters*
ST. LOUIS, MO.	214	KFWF
ST. LOUIS, MO.	545	KSD
ST. LOUIS, MO.	275	WCK
ST. LOUIS, MO.	273	WEB
ST. LOUIS, MO.	280	WEW
ST. LOUIS, MO.	280	WMAY
ST. LOUIS, MO.	263	WRAO
ST. PAUL, MINN.	226	KFOY
ST. PETERSBURG, FLA.	226	WDBI
ST. PETERSBURG, FLA.	258	WHBN
ST. PETERSBURG, FLA.	222	WIBC
ST. PETERSBURG, FLA.	264	WSAG
STANFORD U., CAL.	273	KFGH
STATE COLLEGE, N. M.	266	KFRY
STATE COLLEGE, N. M.	348	KOB
STATE COLLEGE, PA.	283	WPAB
STEVENSVILLE, MONT.	258	KFJR
STEVENSPOINT, WIS.	278	WDBL
STEVENS POINT, WIS.	240	WHBB
STEVENS POINT, WIS.	278	WLBL
STOCKTON, CAL.	360	KWG
STREATOR, ILL.	231	WTAX
SUPERIOR, WIS.	261	WDBP
SUPERIOR, WIS.	242	WEBC
TACOMA, WASH.	250	KFBG
TACOMA, WASH.	252	KGB
TACOMA, WASH.	250	KMO
TACOMA PK., MD.	222	WBES
TAFT, CAL.	258	KFQC
TAMPA, FLA.	365	WDAE
TAMPA, FLA.	250	WGBP
TARRYTOWN, N. Y.	273	WRW
TAUNTON, MASS.	229	WDBE
TECUMSEH, NEB.	242	WTAU
THRIFTON, VA.	226	WGBG
TOLEDO, OHIO	270	WABR
TOLEDO, O.	252	WTAL
TRENTON, N. J.	256	WMAL
TRENTON, N. J.	240	WOAX
TROY, N. Y.	385	WHAZ
TULSA, OKLA.	250	WLAL
TULLAHOMA, TENN.	252	WCBV
TUSCOLA, ILL.	278	WDZ
TUSCON, ARIZ.	368	KFDH
TWIN CITIES, MINN.	416	WCCO
UNIVERSITY PL., NEB.	283	WCAJ
UPLAND, CAL.	211	KFWC
URBANA, ILL.	273	WRM
UTICA, NEB.	224	KFGB
UTICA, N. Y.	273	WSL
VANCOUVER, WASH.	231	KFVL
VALPARAISO, IND.	278	WRBC
VERMILLION, S. D.	283	WEAJ
VIRGINIA, MINN.	248	KFUZ
WACO, TEX.	352	WJAD
WALLACE, IDA.	224	KFOD
WALLA WALLA, WASH.	256	KFCF
WARRENSBURG, MO.	234	KFNJ
WASHINGTON, D. C.	468	WCAP
WASHINGTON, D. C.	234	WDM
WASHINGTON, D. C.	360	WIL
WASHINGTON, D. C.	260	WMU
WASHINGTON, D. C.	468	WRC
WASHINGTON, D. C.	256	WRHF
WATERLOO, IA.	236	WRAN
WEBSTER, MASS.	231	WKBE
WENATCHEE, WASH.	360	KDZI
W. LAFAYETTE, IND.	283	WBAA
WHEATLAND, WIS.	231	WIBF
WHITTIER, CAL.	236	KFOC
WICHITA, KAN.	231	KFOT
WICHITA, KAN.	280	WEAH
WILKES-BARRE, PA.	254	WBAX
WILKES-BARRE, PA.	231	WBRE
WILMINGTON, DEL.	360	WHAV
WILMINGTON, DEL.	360	WOAT
WILMINGTON, N. C.	275	WBBN
WINTER PARK, FLA.	240	WDBO
WOOSTER, O.	234	WABW
WORCESTER, MASS.	238	WCBT
WORCESTER. MASS.	268	WDBH
YAKIMA. WASH.	242	KFIQ
YANKTON, S. D.	248	WNAX
YELLOW SPRINGS, O.	242	WRAV
YOUNGSTOWN, O.	315	WDBF
ZION, ILL.	341	WCBD

Wave-length	*Location*	*Call Letters*
360	Boulder, Col.	KFAJ
260	Brookings, S. D.	KFDY
360	Dartmouth, Mass.	WMAF
360	Decatur, Ill.	WBAO
360	Hamilton, O.	WRK
360	Havre, Mont.	KFBB
360	Honolulu, Hawaii	KGU
360	Houston, Tex.	WEAY
360	Houston, Tex.	WSAV
360	Johnstown, Pa.	WTAC
360	Los Angeles, Cal.	KWH
360	New York, N. Y.	WHN
360	New York, N. Y.	WQAO
360	Oakland, Cal.	KZM
360	Ogden, Utah	KFCP
360	Okmulgee, Okla.	WPAC
360	Phoenix, Ariz.	KFAD
360	Philadelphia, Pa.	WWAD
360	Shreveport, La.	KFDX
360	South Bend, Ind.	WGAZ
360	Stockton, Cal.	KWG
360	Washington, D. C.	WIL
360	Wenatchee, Wash.	KDZI
360	Wilmington, Del.	WHAV
360	Wilmington, Del.	WOAT
361	Oakland, Cal.	KGO
365	Kansas City, Mo.	WDAF
365	Kansas City, Mo.	WHB
365	Tampa, Fla.	WDAE
368	Tuscon, Ariz.	KFDH
369	Mishawaka, Ind.	WOAO
370	Chicago, Ill.	WEBH
370	Chicago, Ill.	WGN
375	Hot Springs, Ark.	KTHS
379	Schenectady, N. Y.	WGY
384	Miami Beach, Fla.	WMBF
384	Seattle, Wash.	KFOA
384	Seattle, Wash.	KJR
385	Troy, N. Y.	WHAZ
389	Cleveland, O.	WEAR
389	Cleveland, O.	WTAM
392	San Antonio, Tex.	WOAI
394	Bristow, Okla.	KFRU
394	Philadelphia, Pa.	WDAR
394	Philadelphia, Pa.	WFI
399	Louisville, Ky.	WHAS
405	Los Angeles, Cal.	KHJ
405	Newark, N. J.	WOR
416	Twin Cities, Minn.	WCCO
417	Minneapolis, Minn.	WBAH
417	Minneapolis, Minn.	WLAG
422	Cincinnati, O.	WLW
428	Atlanta, Ga.	WSB
428	San Francisco, Cal.	KPO
440	Cranston, R. I.	WDWF
440	Jefferson City, Mo.	WOS
447	Chicago, Ill.	WMAQ
447	Chicago, Ill.	WQJ
452	Baltimore, Md.	WFBR
454	Seattle, Wash.	KTW
455	New York, N. Y.	WJY
455	New York, N. Y.	WJZ
461	Pittsburgh, Pa.	WCAE
468	Los Angeles, Cal.	KFI
468	Washington, D.C.	WCAP
468	Washington, D. C.	WRC
472	Dallas, Tex.	WFAA
475	Boston, Mass.	WEEI
476	Fort Worth, Tex.	WBAP
484	Davenport, Ia.	WOC
485	New York, N. Y.	WEAF
491	Portland, Ore.	KGW
492	New York, N. Y.	WBAY
498	Iowa City, Ia.	WSUI
503	Memphis, Tenn.	WMC
508	Oakland, Cal.	KLX
509	Philadelphia Pa.	WIP
509	Philadelphia, Pa.	WOO
516	Detroit, Mich.	WCX
526	Des Moines, Ia.	WHO
526	New York, N. Y.	WNYC
526	Omaha, Neb.	WOAW
535	Chicago, Ill.	KYW
535	Madison, Wis.	WHA
545	St. Louis, Mo.	KSD
549	St. Louis, Mo.	KFUO

HINTS FOR AMATEURS

Conducted by Albert G. Craig

How to Sharpen up a Tuned Radio-Frequency Receiver

When a tuned radio-frequency receiver is located close to a powerful broadcasting station, it is often difficult to tune out the local signals and receive signals from a distance.

One way to help sharpen up reception with such a receiver is to include, directly in the antenna circuit, a small fixed condenser. It is advisable to obtain four condensers to make a try-out. The sizes for these condensers should be .0001 mfd., .00015 mfd., .00025 mfd., and .0005 mfd. Place these in the antenna circuit, one at a time, and tune to the different stations on various wavelengths, until you find the one which gives sufficient selectivity with the best volume from out-of-town stations.

The one you choose may be left "in" all the time, or it may be used with a short-circuit switch only when the local broadcasts are going full blast.

For greater distance reception, after the local broadcasting has stopped, it would be advisable to close the short-circuit switch, which would give a direct connection to the antenna.

A Tip on Soldering

When soldering the several pieces of wire together in constructing an antenna, it is advisable to clean the parts of the wire to be soldered by scraping them with a knife or a file until they are bright and shiny. When this has been done, it will be much easier to make a good soldered connection that will be permanent.

This same procedure will insure good connections inside of the set itself at the time when the wiring is being done.

A Guide When Buying a Ready-made Receiver

In deciding on what kind of a receiving set one might want to buy, it is recommended that the prospective purchaser consult the department in this magazine, "What Set Shall I Buy?" Every month this series illustrates a number of excellent receivers of various designs and types, and gives data showing how much they cost, what kind of ærials are used with them, how many tuning controls they contain, what kind of batteries are used and what their average distance ranges are. The sets shown in every issue vary from the less expensive to the very costly grades.

Ask your dealer to demonstrate to you one or two of the models that you pick from this series.

Do Not Use Paint

Never use any kind of ordinary paint on a radio receiver. Do not paint the baseboard with any regular colored paint; use some sort of a vegetable stain for this purpose and dry it out thoroughly before it is installed in the set. Never use any kind of varnish for the coils or tuning units in a receiver.

CONDUCTED BY LAURENCE M. COCKADAY

In justice to our regular subscribers a nominal fee of fifty cents per question is charged to non-subscribers to cover the cost of this service, and this sum must be inclosed with the letter of inquiry. Subscribers' inquiries should be limited to one question or one subject.

Audio-frequency Transformer Leads

QUESTION: I have been experimenting in making my own audio-frequency transformers, and I have had a lot of fun in varying the different constants and then testing them out to see just what difference the various changes made. What is the proper way to connect the coils, primary and secondary? I have the secondary coil wound outside of the primary coil with a shell type core. Please tell me the best way to bring out the leads to the grid, filament, plate and B (+)?

F. LINDSAY

ANSWER: The outside end of the secondary winding should go to the grid of the vacuum tube. The inside end of this winding should go to the negative filament or to the negative (—) "C" battery (when one is used).

The outside end of the primary winding should go to the "B" battery (+) and the inside end of the primary winding should go to the plate of the tube. This gives the lowest capacity between the grid and plate ends of the windings, which lowers the effective capacity across the coils.

A By-pass for First Audio Transformer

QUESTION: Is it a good practice to use a by-pass condenser across the primary of the first audio transformer in a radio receiving set? In some sets I noticed that it makes little difference—in other sets it makes a whole lot of difference. Just why is this and what size would you prescribe for ordinary receivers?

F. THIELE

ANSWER: A by-pass condenser in this position usually is of considerable benefit in a radio receiving set.

Some transformers have a large enough distributed capacity between the turns of the primary winding, so that the by-pass condenser is not necessary. However, it is usually good practice to include across the primary of the transformer, a condenser varying between .0001 mfd. and .0005 mfd. Larger sizes than this may tend to by-pass some of the audio-frequencies, especially the high ones that help so much in reproducing the consonants in speech.

Soldered Connections Inside Receivers

QUESTION: Do you recommend soldering connections inside a home-built receiver or just attaching the wire under the binding posts with which the instruments are equipped? I notice that the larger manufacturers are equipping their instruments with soldered lugs. Is this an indication that the soldered connection is better?

M. H. WEINTZ

ANSWER: We recommend using the soldering method throughout, as it insures better and more lasting contact. We also have been recommending to manufacturers that they include soldered lugs on all of the terminals of their parts and instruments, whether or not they equip them with binding posts.

When to Use Straightline Condensers

QUESTION: Do you advise changing the condensers I have in my present four-circuit tuner from the straightline capacity type to the straightline wavelength type, or the more recent development—the straightline frequency type of condenser? On my present set I do not find any trouble when separating the lower wavelength stations, but a friend tells me that I would get much better signal strength if I were to change to the straightline-frequency type of variable condenser. Is this true?

V. REUSCHER

ANSWER: We do not recommend changing the condensers you are using. It is true that straightline-wavelength and more especially straightline-frequency condensers will give less crowding of stations on the dial at the lower wavelengths, but if the capacity and inductance ranges of the receiver are properly proportioned, the trouble of crowding in tuning over the regular broadcast range will not be severe.

The most compact type of condenser, of course, is the straightline-capacity condenser, with the straightline-wavelength type running second and the straightline-frequency condenser finishing up a bad third in regard to space they take up in a receiving set.

As the signal strength in a receiver is dependent upon the electromagnetic and electrostatic fields inside of the receiver, it is always advisable to keep coils and condensers as small as possible in order to limit the size of both of these fields, so that they will not induce currents in other parts of the circuit where the energy might be wasted.

For this reason, we recommend the more compact apparatus and this includes the use of the straightline capacity condenser.

The Water Meter

QUESTION: I notice that my cold-water pipe is not as good a ground as the radiator system in our house. I always understood that the cold-water pipe as a ground was the best of any of them. Can you tell me why this is and how to overcome it?

M. PILAT

ANSWER: There is sometimes a considerable amount of resistance across the water meter in the cellar.

Procure two ground clamps and attach them, one on each side of the meter, to the incoming and the outgoing pipes and connect the two ground clamps together by a No. 14 copper wire. This will reduce the resistance of your ground circuit and probably will make reception on the water pipe even better than it is at present on your radiator system.

The Use of the Power Amplifier

QUESTION: Is it possible to use a power amplifier in connection with my Freed-Eisemann receiver? I have a Western Electric amplifier and horn, but I do not know how to connect it to the receiver.

L. MILLER

ANSWER: Connect the two "input" binding posts of your amplifier to a plug which should be inserted in the detector or first-stage jack of your receiver. Never use the second-stage jack or the quality will be very poor. Use separate "A" and "B" batteries for the power amplifier and keep the horn placed in a location as far away as possible from the receiving set itself.

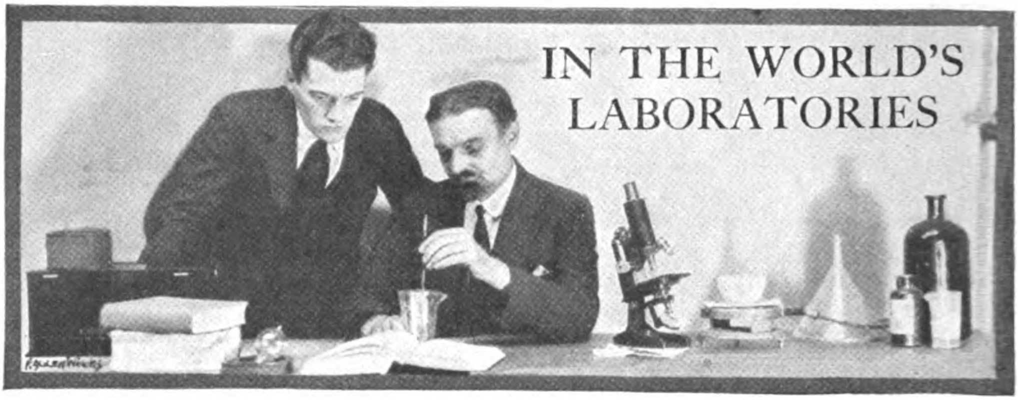
How to Reduce Excessive Plate Current in an Amplifier

QUESTION: I have a three-stage transformer-coupled audio-frequency amplifier using two UV-201-a tubes and one 216-a tube with 90 volts on the plates of the first two tubes and 135 volts on the plate of the 216-a tube. My "B" batteries lasted me less than a month. I borrowed a milliammeter and found that the total plate current was more than 30 milliamperes. Is there any way in which I can reduce the drain on the "B" batteries without decreasing the volume of the signals?

C. ROVER

ANSWER: What you need is a "C" battery. The "C" battery voltage on the grids of the first two tubes should be about 4½ volts. The "C" battery voltage on the grid of the last tube (the 216-a tube) should be 9 volts with the plate voltages that you are using. To connect the "C" batteries break the wire running from the filament to the terminal marked F on each of the transformers. Then connect the positive of the "A" battery to the filament wire and connect the 4½-volt tap to the terminals marked F on each of the first two transformers. Then connect a 9-volt tap which, of course, would be 9 volts negative, to the terminal marked F on the third transformer.

This will give a negative bias of 4½ volts on the first two tubes and 9 volts on the last tube.



IN THE WORLD'S LABORATORIES

CONDUCTED BY DR. E. E. FREE

Earth Screens for Radio Reception

THE use of an earth screen, composed of wires stretched along the ground under the antenna, is already usual in transmitting stations and it has been proved that a considerable lowering of the antenna resistance can be accomplished in this way. The theory is a little complicated but what happens essentially is that the wires of the screen serve as an attachment for the lower ends of the lines of electric force the upper ends of which arise from the antenna.

Another way of looking at it is to consider the antenna-to-earth's-surface system as a condenser. The antenna is one plate; the earth's surface is another plate. A metallic-wire screen placed underneath the antenna acts as a substitute for the earth's surface. The screen becomes the lower plate of the condenser. Naturally a set of highly-conductive wires has a lower resistance than the earth. Also it is more perfectly attached, electrically, to the transmitting apparatus. The net effect, then, is as if you substituted a good, metallic condenser, with its two plates exactly opposite to each other, for an imperfect condenser one plate of which was made of poorly conducting material.

In the case of transmitting systems all this has been well-known for two or three years. Recently, however, two scientists at the British National Physical Laboratory, at Teddington, England, have completed a series of experiments on the application of this same earth-screen idea to receiving antennas, including antennas used in ordinary broadcast reception.*

There is no theoretical reason why this should give any especial improvement of reception. The problems of transmitting antennas are very different from those encountered when the antenna is to be used for reception only. Nevertheless, actual tests proved that an earth screen really does give a considerable advantage in reception as well as in transmission. With three of four wires arranged a few feet above the ground, underneath the antenna and parallel to it, the received current was found to be approximately twice as great and the antenna resistance approximately one-half that found when a water-system ground of usual type was used.

In order to make use of as many as three or four such wires in an earth screen it is necessary to fence off the land under the antenna, a procedure which is seldom possible to the ordinary radio fan either in England or in America. But what can be done, in many instances, is to provide *two* wires stretched parallel to the antenna and more or less underneath it. For example, if the antenna wire runs the length of a long narrow lot or garden like the usual city "backyard," it is possible to stretch the two wires along the tops of the two side fences of the yard.

This procedure was tested by Dr. Smith Rose and Mr. Colebrook and was found to be almost as satisfactory as the three or four parallel wires with which the main experiments were made. In one test the two-wire screen system gave an antenna resistance of 13.5 ohms as against 10 ohms for the four-wire screen. In contrast with these low values, the antenna resistance when a water-system ground was employed was in the neighborhood of 25 ohms.

It is apparent, of course, that the advantage of low antenna resistance is of much greater practical importance with crystal sets or other sets having no great amplification and no source of local energy than it is in the multi-tube, high amplification sets now common in the United States. Nevertheless there are many circumstances under which the two-wire, garden fence screen device of Dr. Smith Rose and Mr. Colebrook is well worth trying.

In the same paper these gentlemen report, also, some experiments on the effect of the height, length and wire spacing of the antenna on the strength of the received signal and on the antenna resistance. The signal strength increased with the antenna height up to 25 feet above the earth screen, which was the greatest height tested. The signal strength also increased steadily with increasing length of the (single) antenna wire up to 60 feet. Between 60 and 90 feet there was some increase of signal strength, but much less in proportion than occurred with length increases up to 60 feet. With two-wire antennas the spacing made comparatively little difference in the signal strength, although there was some increase as the spacing was increased, between the limits of one foot and eight feet.

---

* "Some Experiments with Aerial and Earth Systems for Reception," by R. L. Smith Rose and F. M. Colebrook. *Experimental Wireless* (London), vol. 2, pages 207-217 (January, 1925).

The entire investigation marks what may prove, it is to be hoped, the beginning of the application to broadcast reception problems of the same precise and careful methods of investigation which have been used with so much success in the design of transmitting equipment for the larger stations.

Musical Echoes from Iron Railings

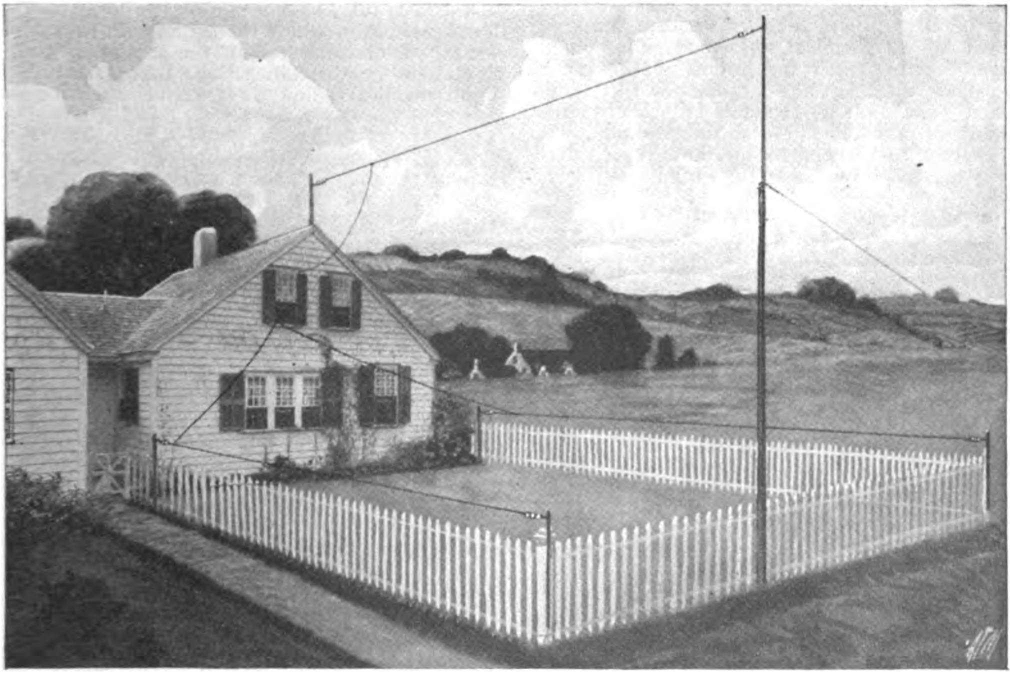
A CURIOUS phenomenon of sound waves, not without interest to the student of radio reproduction troubles, was described recently in a London weekly by Sir R. A. S. Paget, the distinguished British physicist.* Sir Richard is discussing the multiplicity and interest of the London echoes; how the busses go sh-sh as they go past the posts of a gateway, how you can "hear" the open spaces of a side street that you pass, and the like. It is possible, he continues, to produce a musical tone, in the character of a thin, reedy whistle, merely by walking past a length of iron railing, a series of vertical iron bars erected as a fence.

The cause is a selective echo of the claps of your feet on the pavement. "Your footfall made," he says, "but a single explosive sound, but the wave of sound which was then produced traveled out in all directions, and some of it hit the railings. As it reached each upright rod in turn a little of the sound (no doubt some of the very short waves which formed part of the original 'clap') was reflected back, and so reached your ear. The sound takes time to travel, and, therefore, the original sound reaches each succeeding upright of the railings a little later than the last. In the same way the echoes each take a little longer to get back, according as they come from uprights which are farther and farther away. The consequence is that the echo of the original clap comes back to our ears not as a single clap, but as a rapid succession of infinitesimal claps, reflected by the succession of upright rods which form the fence."

The interval of time between each tiny, reflected sound impulse depends upon the distance between the upright bars of the fence. This, of course, determines the pitch of the musical note produced by their combination.

---

* "'Listening-In' to London's Echoes," by Sir R. A. S. Paget. *The Graphic* (London), February 14, 1925, page 232.



From a drawing by Arthur Merrick for POPULAR RADIO

HOW TWO WIRES MAY BE USED FOR AN EARTH SCREEN

The wires strung along the top of the two fences make an earth screen like those tested by Dr. Smith Rose and Mr. Colebrook. There is said to be a considerable improvement for reception as well as for transmission.

Sir Richard's casual observation has more to it than a mere curious incident. It is unlikely, it is true, that gangs of men tramping past rows of iron railings will ever be used to constitute an orchestra. But this phenomenon of repeated echoes, combining or reinforcing each other, is already of considerable importance in the science of acoustics. A year or two ago some one patented an anti-static device based on this principle. Rows of slats reflected the desired sounds, letting the others pass through. Other anti-static sound filters have been suggested.

Good quality radio involves problems of sound production and distribution as well as problems in electricity. We have gone farther with the electrical problems than we have with the acoustic ones. The sound experts must catch up. It is quite possible that difficulties with this or that broadcasting studio or receiving room may be due to reflections of sound waves, rather than to bad tuning or poor modulation. The Editor of this department has heard a dozen chairbacks, all set up in a row, make a most disturbing echo, not unlike that of Sir Richard's musical fence.

Helium Yields to Chemical Combination

STUDENTS of modern atomic theory have been accustomed to regard helium as the invincible spinster among the chemical elements. While most of the elements in the list combine readily with each other to form the long list of known chemical compounds, the helium atom, together with the atoms of the other so-called "inert" group—argon, neon, krypton, xenon and niton—remain stubbornly resistant to any kind of chemical union. It is exactly this chemical inertness which has made helium so valuable for airship use, as it does not possess that avidity for oxygen, which makes hydrogen so inflammable and so dangerous.

Now, however, we have the most revolutionary announcement that helium can be made to enter into chemical combination after all. Last December Dr. J. J. Manley reported the apparent formation of a chemical compound between the mercury atom and the helium atom.[*] Now Dr. E. H. Boomer, of the famous Cavendish Laboratory of Cambridge University, England, believes that he has succeeded in producing compounds of helium with mercury, iodine, sulphur and phosphorus.[†] These compounds are relatively stable at the temperature of liquid air.

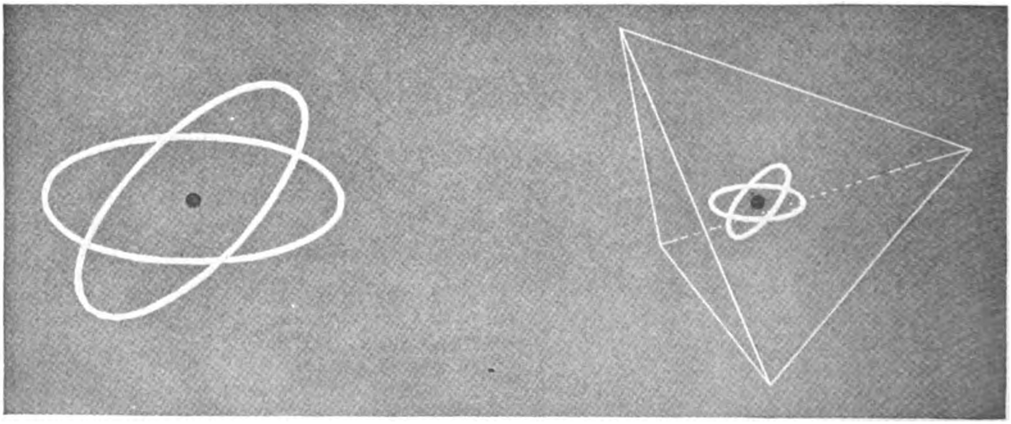
The importance of these results, should they be confirmed, will not lie so much in the mere conquest of the aloofness of helium. It will lie in the fact that one of the atoms believed, on grounds of modern atomic theory to be completely "satisfied," so that no attractive power remained for chemical combination, turns out not to be completely satisfied after all.

Fortunately, no atomic theories will need to be abandoned. It has already been suggested by the distinguished German physicist, Professor Franck, that there are *two* varieties of helium atoms, differing from each other in having slightly different arrangements of the orbits in which the two electrons of helium revolve. It is assumed by both Dr. Manley and Dr. Boomer that the apparent helium compounds which have been obtained are produced, in reality, by the one of the two varieties of helium in which the arrangement of the electron orbits does permit the retention of a very slight residual attraction; that is, a very slight chemical affinity.

---

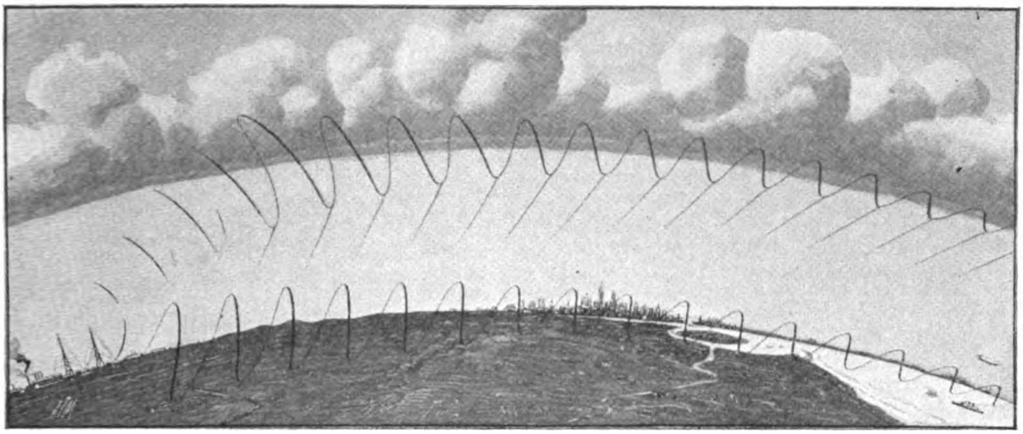
[*] *Nature* (London), vol. 114, page 861 (December 13, 1924).

[†] *Nature* (London), vol. 115, page 16 (January 3, 1925).



ONE OF THE MOST INERT OF ATOMS

The diagram at the left shows the two electron orbits in an atom of helium—an element always supposed to be virtually incapable of chemical combination. This same group of two electron orbits exists inside many other atoms; as, for example, in the carbon atom shown in outline at the right.



Courtesy Scientific American

THE NEW DOUBLE-PATH IDEA OF RADIO TRANSMISSION

Evidence obtained at the time of the recent eclipse of the sun indicates that radio waves move simultaneously along two paths; one close to the ground surface, the other in the higher levels of the atmosphere.

New Ideas of the Heaviside Layer

READERS of POPULAR RADIO cannot have forgotten the discussion which was carried on so vigorously some months ago concerning the relative accuracy of two theories of the transmission of radio waves around the earth, the Gliding Wave Theory and the Heaviside Layer Theory.[*] There was much to be said for each side to this controversy and it now appears, as happens so often in scientific controversies, that both sides were right. The actual transmission of radio waves along the curved surface of the earth appears to involve *both* a gliding wave along the ground (or the sea) and a second part of the wave which passes through the upper part of the atmosphere in the region commonly set aside for the supposed Heaviside Layer.

It has been necessary, however, to modify somewhat the supposed properties of this famous Layer. In the earlier theories the Layer was thought of as a kind of mirror for the radio waves. The waves were supposed to be reflected from the under surface of the Layer. Thus, by a succession of such reflections, the train of waves was curved to correspond with the curvature of the earth. The newer idea contemplates a bending of the waves rather than a reflection. The upper part of the air is more highly ionized. Therefore it is slightly conducting. This makes the upper part of the wavefront move a little faster than the lower part. The result is that the wave bends.

This conclusion was forecast, quite clearly, in Dr. Fessenden's article in POPULAR RADIO referred to in the footnote. It was again emphasized last winter in an important paper by Sir Joseph Larmor[†] Important contributions have been made, also, by the distinguished British radio expert, Dr. W. H. Eccles, and the most cogent evidence of all has been secured, quite recently, as a result of the radio investigations made by the well-known American experimenter, Mr. Greenleaf W. Pickard,[‡] during the eclipse of the sun.

Actual radio transmission, Mr. Pickard has shown, is probably accomplished by two paths. First is a wave that travels close to the ground. This corresponds to the "gliding wave" of the older hypotheses. It is especially effective close to the transmitting station. Second, there is another wave which travels along the upper levels of the atmosphere and is bent around the earth as described by Dr. Eccles and Sir Joseph Larmor. This upper wave is responsible for most of the reception at a distance.

The reason why reception at great distances is possible with such low power—as has been evidenced by so many amateur records—is that the transmission of this upper part of the wave is very nearly without loss. Once the wave sent out by a transmitter has penetrated the lower levels of the atmosphere and reached this upper, conducting layer, its further progress depletes its strength very little.

---

[*] "Is the Heaviside Theory Valid," by Elihu Thomson, POPULAR RADIO for December, 1922, pages 231-235; "What Bends Radio Waves," by Sir Oliver Lodge, POPULAR RADIO for January, 1923, pages 3-9; "What Really Guides Radio Waves," by Major General George O. Squier, POPULAR RADIO for March, 1923, pages 184-187; "How Ether Waves Really Move," by Reginald A. Fessenden, POPULAR RADIO for November, 1923, pages 337-346.

[†] "Why Electric Rays Can Bend Round the Earth," by Sir Joseph Larmor, *Philosophical Magazine* (London), vol. 48, pages 1025-1036 (December, 1924). The paper was presented originally at the Cambridge Philosophical Society on October 27, 1924, and an abstract was published in *Nature* (London), vol. 114, pages 650-651 (November 1, 1924). There is a brief additional note in *Nature* for April 18, 1925 (vol. 115, pages 566-567).

[‡] Mr. Pickard's results were reported to the Institute of Radio Engineers (New York) on April 1, 1925, in a paper entitled "Effects of the Solar Eclipse on Radio Reception," which paper will be published in the *Proceedings* of that institute. Another brief report by Mr. Pickard is given in *QST* X (Hartford, Conn.), vol. 9, number 4, pages 24-25 (April, 1925). Additional reports of the eclipse observations are presented in an article entitled "The Effects of the Eclipse on Radio," by Alfred P. Lane and F. X. Walsh, *Scientific American* (New York), vol. 132, pages 224-226 (April, 1925).

Why this is so is a story too long for this brief note. It is one result of the fact that the air atoms at that height are relatively very far apart and are considerably electrified. A full account of these facts, as well as of the details and implications of these newer theories of tradio transmission, will be presented in a special article in an early issue of POPULAR RADIO.

A Promising Static Eliminator

AN anti-static device which seems much more promising than most is announced as the invention of Dr. Galen McCaa.* It is not, strictly speaking, a static eliminator, for the static is not entirely eliminated. What the device does do, it is reported, is to reduce the static to the signal level, both static and signal having the same intensity in the receiver and in the headphones.

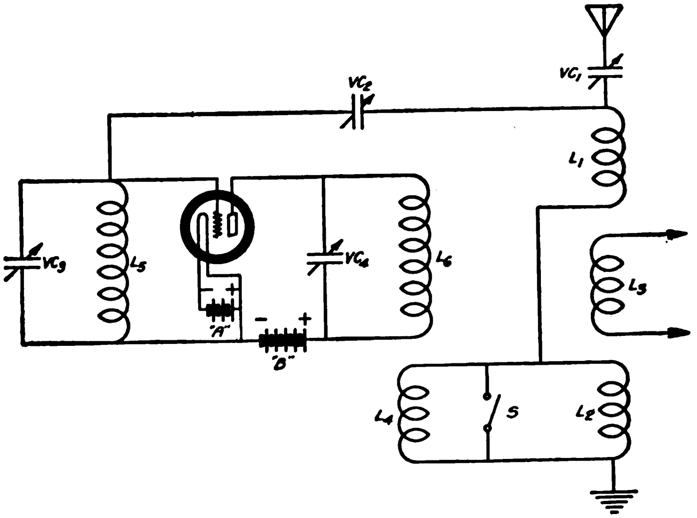
The device begins with the familiar principle of two primary coils in the antenna circuit, these being coupled in opposite fashion to the secondary and thence to the receiver. With proper adjustment of the coupling, these two primary coils may be made to balance out each other so that nothing—neither signal nor static—gets through into the secondary. The practical problem is to balance out the static and let the signal through.

Dr. McCaa accomplishes this by adding another coil of somewhat high inductance in parallel with one of the two primaries. In addition, there is a special control circuit containing a vacuum tube oscillator and coupled inductively to the added, high-inductance coil. The hook-up will be clear from the diagram herewith.

The action of this control circuit on the high-inductance coil is to alternately increase and decrease the effective impedance of the latter; in step, of course, with the oscillation of the control circuit. By adjusting the coupling this can be so arranged that the impedance of the inductance coil becomes periodically almost zero, thus shorting the primary coil with which this inductance is in parallel. The result is that the other primary coil is then able to affect the secondary coil, so that a signal (or static) impulse is heard in the receiver.

It is one of the characteristics of static that it produces, in general, a greater voltage in the antenna circuit than does the signal. Accordingly, the couplings of the McCaa circuits can be so arranged that this excess voltage due to static prevents, while it lasts, the shorting of the second primary by the inductance coil and the control circuit. Thus any static impulse stronger than the signal impulse for which the coupling is adjusted will not be passed into the secondary. The device is essentially one for the limiting of strays of any kind to the same intensity as that of the received signal. It is said that this produces, in practice, much the same impression as though the static were eliminated altogether.

For radio telegraphy the control circuit may be driven without reference to the frequency of the incoming signal. For telephony, however, the signal itself is made to operate the driving tube of the control circuit, as is illustrated in the hook-up reproduced herewith.



DR. McCAA'S SUGGESTION FOR REDUCING STATIC

The coil L3 is the secondary, connected to the receiving circuit. Of the two primaries, L1 and L2, the latter is connected in parallel with a fairly high inductance, L4, the impedance of which is periodically canceled by the central circuit connected to L6. The theory of the device is described above.

---

*"The McCaa Anti-Static Devices," by S. Kruse. *QST* (Hartford, Conn.), vol. 9, number 2, pages 8-12 (February, 1925); number 3, pages 18-23 (March, 1925). The second article contains constructional details.

Radio Interference from Clouds of Steam

PHYSICISTS have long known that visible clouds of water particles, such as the "steam" given off by a puffing locomotive, are electrified. The electricity seems to be produced merely by the separation of the water into the tiny droplets, although the exact mechanism of this electrification is still imperfectly understood.

Recently two authors have suggested independently that such electrified clouds may cause, in special circumstances, local interference with radio.* It has been observed that the electrified clouds show perceptible attractions and repulsions when they approach high-voltage transmission lines. In one instance the cloud has been observed to pulsate at a rapid frequency, an effect caused, perhaps, by an alternating potential on the nearby charged lines.

Radio interference thus caused might be of two kinds. One is the creation of strays, which would appear in nearby receivers as a variety of static. The other is a possible effect of such charged clouds in absorbing or deflecting incoming waves. It is well known that the radio interference of both kinds is much greater in factory towns than in the country and is far greater in the daytime (in cities) than it is at night. This has usually been ascribed to the operation of electric motors and no doubt that is where most of the blame belongs. But it may be that we will need, also, to look into the radio effects of the continuous steam clouds from locomotive yards and from factory chimneys.

---

* "The Positive Electrical Drift in the Air," by William C. Reynolds, *Nature* (London), vol. 115, page 531 (April 11, 1925); "High Tension Electric Lines and the Discharges of Steam Locomotives" (in French), by P. L. Mercanton, *La Nature* (Paris), number 2,663, page 255 (April 18, 1925).

Brown Bros.

DOES SMOKE CAUSE INTERFERENCE?

Smoke and steam are electrified. It is possible that the clouds produced may interfere in several ways with nearby radio reception.

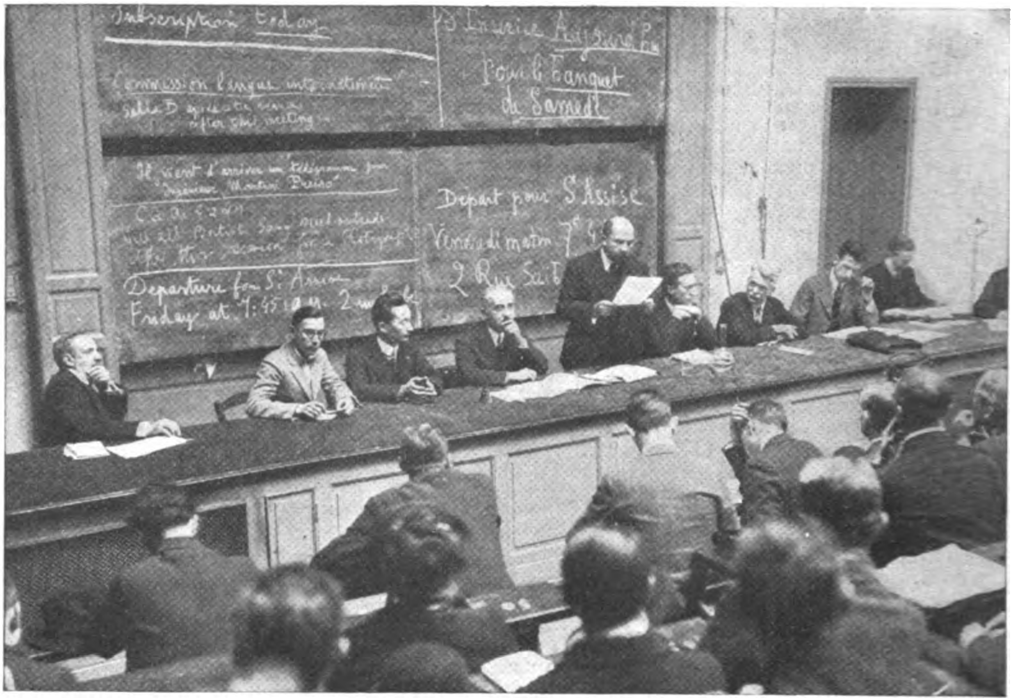
A New Record for Pictures by Radio

ON May 6, 1925, a new record was established for the sending of pictures—in this instance photographs—by radio. Practice war maneuvers were in progress off the Hawaiian Islands. The officers of the War and Navy Departments wished to report the results as fully and completely as possible to their superiors in the United States. By the aid of the facilities of the Radio Corporation of America illustrative photographs to accompany the report were sent by radio, traversing a distance of over five thousand miles in approximately twenty minutes.*

The route followed included three land-wire links and two radio links. First the signals corresponding to the pictures were sent by wire to station KIE in the Hawaiian Islands. From here a 16,975-meter wave carried them to a receiver at Marshall, Cal. Thence a second land wire took them to KET, at Bolinas, Cal., which station again put them on the air on a wavelength of 13,100 meters. This wave was picked up at the receiving station of the Radio Corporation at Riverhead, L. I., where the signals were again put on a land wire to the picture-reproducing apparatus in New York City. The system used was substantially the same as has been employed for some months in the well-known experiments of the Radio Corporation in the radio transmission of pictures. It is already apparent that this system might prove of the greatest value in case of war or other national emergency.

---

*Details are given in an account, credited to Captain R. H. Ranger, of the Radio Corporation of America, in the *New York Times* for May 10, 1925.



Delano Service

AMATEURS FORMALLY ADOPT A "UNIVERSAL RADIO LANGUAGE"

One of the actions of the First International Radio Congress (which was recently held in Paris) that is of interest to radio fans everywhere was the adoption of Esperanto as the official "internationally-understood" language of radio. Twenty-one broadcasting stations abroad are now using it.

The BROADCAST LISTENER

Comments on radio programs, methods and technique —from the point of view of the average fan

By RAYMOND FRANCIS YATES

The Waning "Art of Jazz"

FOR three years now we have been ranting semi-frantically about the unmitigated employment by the studios of the zoölogical brand of music. Go to the radio any evening and you will find anywhere from five to ten jazz orchestras within the reach of your contraption. And the tragedy of it is the growing number of "fox-trot versions." If it is not the mangled body of a Wagner aria it is a Strauss waltz or a Chopin prelude. This simply goes to show that jazz is a bankrupt art and that syncopation is a musical parasite feasting on the luxurious fiber of creations far beyond the capabilities of its own masters. It is just as easy to syncopate the Flower Song as it is to sit down at the piano and rag Moritz Moszkowski's Serenata Opus 15, No. 1. Yet to hear our jazz mongers talk, one would think that jazz was a great, big, healthy, artistic invention that must be fed from the deepest wells of human emotion.

Radio has made jazz so hopelessly common that it is hurting both itself and broadcasting. Still, we have only a few studio managers in this big country of ours who are able to put their minds around this simple fact. We do not mean to say that jazz should not be allowed a place on the air or that all of its practitioners should be given a long rest at the Bide-a-Wee Sanitarium, for, after all, some of its supporters have been able to lift it, not to an art, but to a sort of craftsmanship that deserves some kind of recognition. No one can listen to the gentle playing of Paul Whiteman and his original band without feeling kindly toward this drooling infant of the musical world. Lopez, too, has given more to radio than radio has given to him. Fortunately for jazz and the radio, Lopez is not what we call a "musical smarty." He does not take pride in trying to crush music into an unrecognizable pulp with the newer devices and methods. There is a charm, a warmth, a gentle flavor to his playing that one, even though hostile to jazz, must sympathize with. That Lopez is spending his time in the development of a hopeless musical protégé makes little difference; he is responsible for a vast source of entertainment.

It would be unfair to Ben Bernie (another WEAF feature) not to mention him along with the precious few. Bernie has an enjoyable technique all his very own and it seems to us that he has supplied jazz with some real originality.

* * *

Politicians Take the Air

If there is one thing that is hurting broadcasting in these great United States, it is stations like WNYC, the "Municipal Voice of Greater New York." WNYC, we are sorry to report, is a political station operated by politicians for politicians. Perhaps it would be wiser to feel charitable toward this experiment, for the gentleman who thinks that he can increase his popularity by filling the air with the raucous voices of his henchmen has yet to learn the resentful nature of the radio audience. If we were king we should never risk our kingship with the fickle radio listeners.

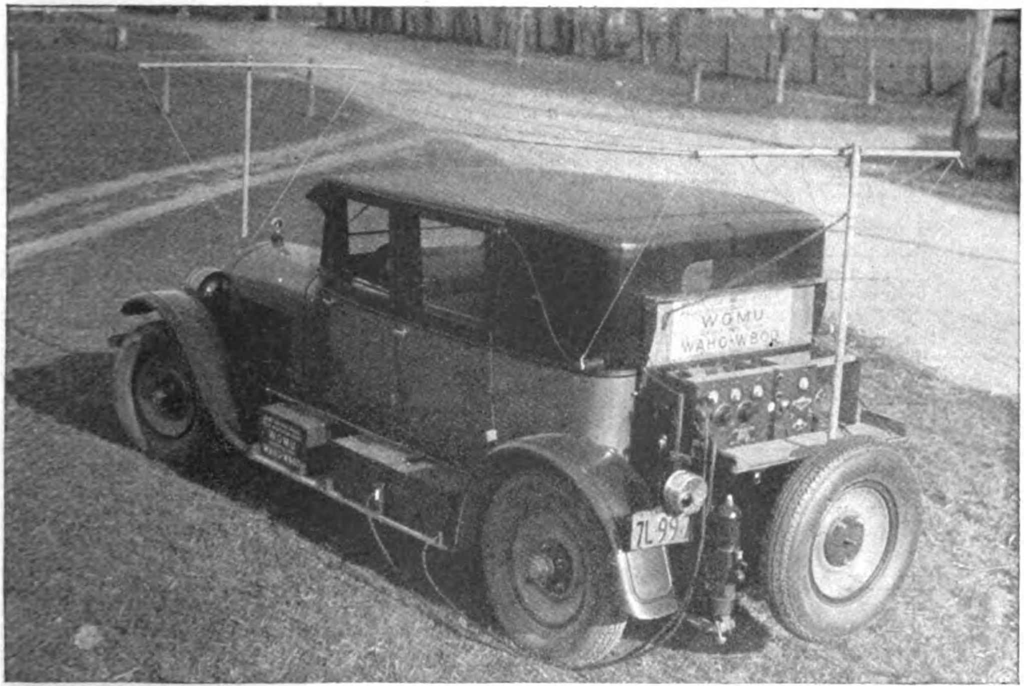
We can only hope for one thing in connection with Mr. Hylan and his broadcasting, and that is that someone is gathering data on the project so some sort of a scientific treatise on "Why Mayors Should not Broadcast" may be prepared after Mr. Hylan has retired to the quiet of his Brooklyn home in 1926.

* * *

How to Read Publicity Notices About Radio Artists

If you want to keep good friends with your radio and avoid those little disappointments that may eventually make you a "radio bolshevist," don't believe all you read in the newspapers about the radio programs. The studio publicity man is a guileless exploiter and he can, with his Smith Premier No. 9, make a third-rate violinist the pet of the Continent or a Chautauqua lecturer the 1925 model of Mark Antony.

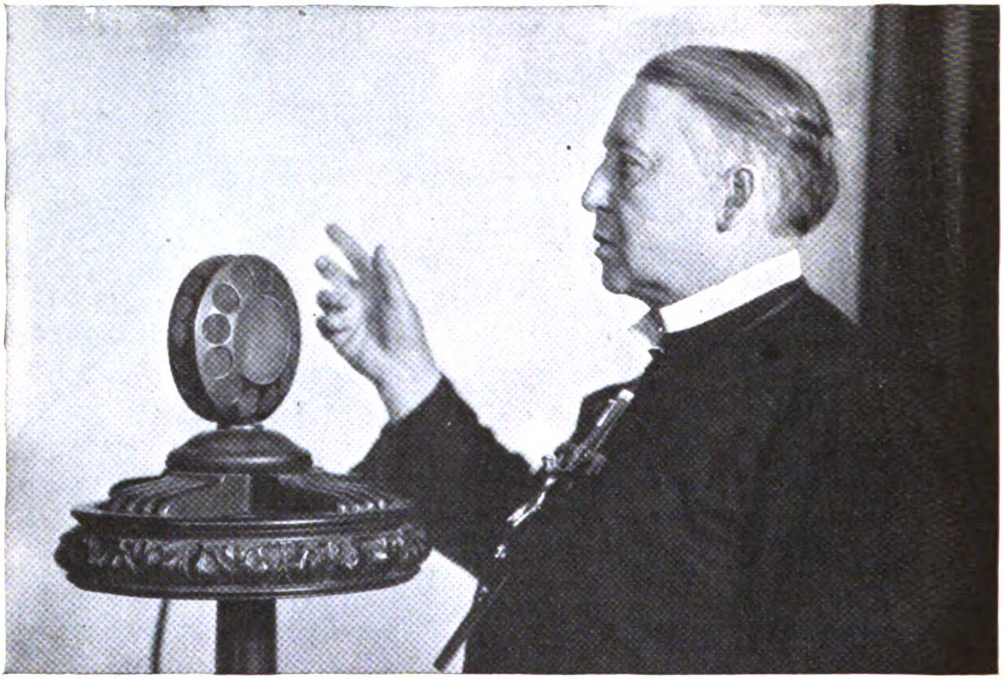
The job of a publicity man, whether at the theater or in the studio, is that of making big people out of little ones and great stars out



Courtesy of the New York *World*

A BROADCASTING STATION THAT GOES TO THE SOURCE OF NEWS

This portable transmitter, sent out from the Grebe station WAHG, has been used successfully to send news to the editorial rooms of the New York World. As the machine speeds along the reporter sends his story to the main office. The movement of the car does not interfere with the smoothness of transmission.



Underwood & Underwood

"PRESENTING THE CATHOLIC POINT OF VIEW ON THE VARIOUS FIELDS OF HUMAN ACTIVITY"

Unlike the Protestant churches, which make extensive use of the independent broadcasting stations for transmitting sermons, hymns and debates on religious topics, the Paulist Fathers are establishing a chain of stations of their own for the frankly avowed purpose of disseminating Roman Catholic propaganda. Father John Handby, the Paulist missionary, is here shown before the microphone of station WPL, conducted for the Paulist League of New York.

of mere fireflies. The laying on of words is usually so thick and so heavy (anywhere from 3 to 47-ply) that the subjects of the notices do not believe them. Indeed, there is a rule to the game (any publicity man will tell you) that states: "Stars are not 'made' until they begin to believe the flattery in their press notices."

If you want to be a good radio listener, it is part of the game to learn to read the press notices about the "stars." Some alertness must be displayed in skimming the buncombe from the surface of the truth and it often happens that the buncombe is so thick that its complete removal leaves nothing for examination.

* * *

Repetitions on Broadcast Programs

It seems that there should be some simple way for overcoming repetition in radio programs. How annoying it is to hear the same number played from several local studios during the course of a single evening. With a little co-operation and by asking the assistance of the people who broadcast, it could be an easy matter for broadcasters to prevent the radiation of much monotonous material. If the program managers of all of the large centers like Chicago, New York, Philadelphia and Boston would meet weekly for the avowed purpose of comparing notes, the repetition tangle soon would be ironed out and this department would be saved a lot of cussing. At times it does seem as though co-operation is the one thing that our studio managers care least about and yet little thought is required to show that the lack of it is one of the things that is hurting broadcasting and hurting it badly.

* * *

The Broadcasting of Advertising

We often hear fear expressed over the fact that our best studios may sooner or later be operated by advertising agencies and that radio broadcasting will become an out and out advertising medium. We don't know what could be more out and out advertising than radio is at the present time. If there is any station on the air that does not have a little advertising axe to grind, we shall be glad to set our intelligence department on its trail, and, if it should be found, to award its sponsor the Nobel Prize or something as good as the Nobel Prize for having taken the rôle of an honest-to-goodness public benefactor.

The Passing of Bedtime Stories

It is encouraging to note that the bedtime story, once such an important part of every station's equipment, and one of the most solidly entrenched traditions of the art, is rolling down the skids of forgotten events just as fast as anything so old and hopeless should roll. The bedtime story was invented in the early days of WJZ and it hung on for a long time eating up a half or three-quarters of an hour with more propitious program material standing by.

WEAF abandoned its juvenile story way back in 1924 and there was barely a ripple of disapproval. Another fond theory of every standardized studio manager exploded quietly.

* * *

Why Is Roxy?

For the first time in our long and colorful career we are going to come out flat-footed and tell this old world that Roxy is still unmatched as a broadcaster and that he will remain unmatched as long as he wants to reserve the little finger on his left hand to direct his broadcasting work while he uses the rest of his fingers to do in the art of presenting movies what no other man in the country has been able to do. Furthermore, we are going to let the world in on his secret; a secret that he told us many times in our inspiring association with him.

Those who are a bit envious of Roxy's standing as the only broadcaster in the United States with a full measure of dramatic imagination, usually account for his success with a faint derogatory smile and "Yes, he is a pretty clever showman." While Roxy is obviously a man of the theater, with a keen theatrical sense of theatrical values, it is superficial and stupid to grant him nothing more substantial than mere showmanship. A dozen and one showmen have tried to emulate him on the air only to find that their success in the theater did not follow them to the microphone and that broadcasting demanded a technique much more intriguing than they had expected.

Roxy is a sanguine person. There is nothing more mysterious about him than simplicity, but mere simplicity can be mysterious enough to baffle the efforts of those who overlook its virtues. Roxy is completely human and anti-artificial. Certainly no one could accuse him of putting on a pseudo-elegance before the microphone. He is just a plain, warm-hearted citizen obeying to the letter the natural impulses from a peculiar grouping of brain cells that we call personality. That he is able to transmit real personality to his audience and that he is at the same time a discreet eighteen-hour-a-day showman with a truly remarkable sense of the things in life that interest other human beings, is a mere act of Providence. Roxy is as safe from emulation as John Sargent, Sir Isaac Newton or any other great genius.

* * *

1882 Pianos

Microphones do work miracles. Have you ever been exposed to the musical slander emitted by the rusty, loose strings of what may have been a piano back in 1882? Perhaps the thing had been made in Peoria or Cincinnati by a manufacturer long since extinct. Such instruments have usually withstood the punishment of four generations of a non-musical family and they are not uncommonly found standing with the trinkets in the parlors of the rural districts. Even the moths have abandoned them for want of more substantial sustenance.

What agony to disturb their repose! They stab the heart of the musically sensitive with a knife so keen that it cuts clear to the soul. Yes, microphones certainly can work miracles. How efficiently they can transform the modern creations of the piano makers into those instruments that were once the pride of Cincinnati and Peoria! And what a complete and deceiving metamorphosis it is!

The piano, due to its wide range of sound frequency, is a most difficult instrument to broadcast. About 70 percent of our studios make a bad job of it and this department is usually carried back to the days when pianos were made with gingerbread fronts and revolving stools with gingerbread feet—usually a nice brass eagle's claw holding a glass ball. What we need is a commission for the study of piano transmission and if such a commission is formed we shall instantly suggest that it visit the studio of WEAF where perfection may be studied to the heart's content.

* * *

Why Not "Curtain Music" for Radio Programs?

If there is one thing necessary for a good entertainment on the radio, it is good curtain music. A few of our broadcasting novitiates appear to agree with us on this point, but how often the curtain rises on an act with an entertainment value comparable with the third-grade graduation exercises of Public School No. 4! We may be old-fashioned, but we have always felt that studios would bring their audiences to an agreeable and acceptable mood by starting off their programs with the right kind of music. Yet in the face of this, we find many of our best broadcasters leading off with the weather report or the financial developments of the day.

How to Build a 5-Tube Receiver with Simplified Control

This next product of the Popular Radio *Laboratory will be described in the next issue of this magazine—for August.*

WHAT'S NEW IN RADIO APPARATUS

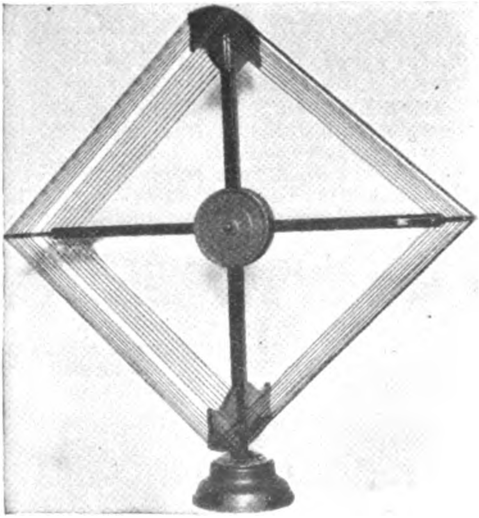
This *department is conducted by* **Popular Radio Laboratory** *for the purpose of keeping the radio experimenter and the broadcast listener informed concerning the newest inventions and the approved developments in radio equipment. Only such apparatus as has been tested and endorsed by the Laboratory is noted in these columns.*

MISCELLANEOUS ACCESSORIES

Mahogany binding post; King Quality Products, Inc.
Mahogany switch lever; King Quality Products, Inc.
K-B adjustable bearing; Koelmel Bros.
Korker combination tool; Korker Products Co.
"Lenk" alcohol blow torch; Lenk Mfg. Co.
"Liberty" terminals; Liberty Transformer Co., Inc.

RADIO-FREQUENCY TRANSFORMERS

"Kellogg" low-loss R. F. transformer No. 602; Kellogg Switchboard & Supply Co.
Vario-transformers; Langbein & Kaufman.
Special air core R. F. transformer; Liberty Transformer Co., Inc.



A collapsible loop antenna.

TUNING INDUCTANCE UNITS

"Kellogg" choke coils; Kellogg Switchboard & Supply Co.
"Kellogg" variometer; Kellogg Switchboard & Supply Co.
"Kellogg" variocoupler; Kellogg Switchboard & Supply Co.
"Universal" variometer; Langbein & Kaufman.
Variable clarifying selector; Langbein & Kaufman.
"Lincoln" oscillascope; Lincoln Radio Corp.
"Lincoln" "Long-45" tuner; Lincoln Radio Corp.
"Lopez" low-loss tuner; A. C. Lopez & Co.

KITS

"Kellogg" kit; Kellogg Switchboard & Supply Co.
"King Quality" kit; King Quality Products, Inc.
"Liberty" Superheterodyne kit; Liberty Electric Corp.
"Lincoln" kit; Lincoln Radio Corp.

GRID-LEAKS AND RESISTANCES

"Kellogg" resistance; Kellogg Switchboard & Supply Co.

AN EFFICIENT LOOP

Name of instrument: Loop antenna.

Description: A really well-made loop of unique design. Four mahogany arms for supporting the wire are fastened to a non-magnetic metal centerpiece, which may be taken apart so that the loop may be folded up into a very small space. Instead of the regular box shape, the wire is formed in a curve. The assembly is mounted on a rotatable shaft with a dial which is calibrated in degrees and equipped with a pointer. The leads are brought out to two terminals in the non-magnetic metal base.

Usage: As a pick-up device for a radio-frequency receiver.

Outstanding features: Portability. Directional efficiency. Good workmanship. Neat appearance.

Maker: The Gowanda Co.

A NOVEL POTENTIOMETER

Name of instrument: Potentiometer.

Description: This instrument is made in accordance with the latest design of the "Bradley" resistance control apparatus. It contains a small rotatable knob at one end with a special lever arrangement for increasing the resistance of one set of carbon discs while at the same time decreasing the resistance of the other set. This gives a very smooth potentiometer arrangement. The three terminals are brought out to screw binding posts.

Usage: Any place where a potentiometer is needed in a radio receiver.

Outstanding features: Compactness. Ease of mounting. Simplicity of connections. Smooth adjustment.

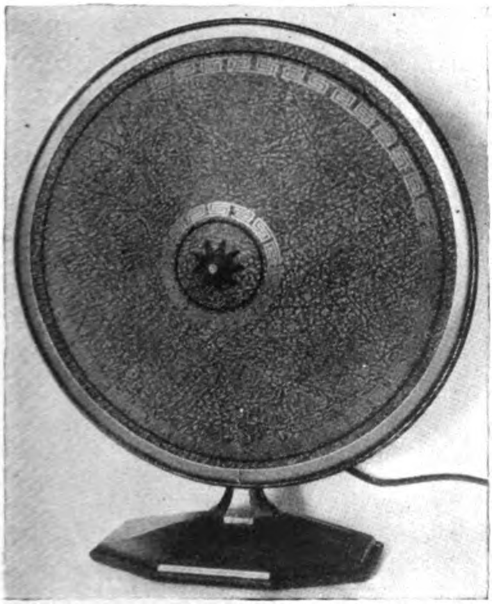
Maker: Allen Bradley Co.

SOCKETS AND ADAPTERS

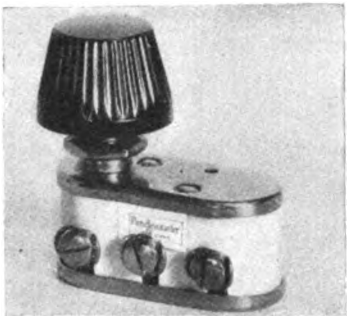
"Kellogg" adapter, No. 501; Kellogg Switchboard & Supply Co.
"Kellogg" V. T. socket; Kellogg Switchboard & Supply Co.
"Keystone" V. T. socket; Keystone Radio Co.
Mahogany panel-mounting tube socket; King Quality Products, Inc.
Adapters; King Quality Products, Inc.
Caldwell socket (type 201); Knox Corp.
"Leich" Improved radio socket; Leich Electric Co.

VARIABLE CONDENSERS

"Kellogg" No. 704 low-loss variable condenser; Kellogg Switchboard & Supply Co.
Variable condensers; King Quality Products, Inc.
"Lincoln" low-loss condenser; Lincoln Radio Corp.
"Lombardi" condensers; Lombardi Radio Mfg. Co.



An attractive new type loudspeaker.



A carbon disc potentiometer.

RECEIVING SETS

Kompentrol receiver; Kardon Products Co., Inc.
"Kennedy" receivers; Colin B. Kennedy Co.
"King Quality" neutrodyne receiver; King Quality Products, Inc.
"Kodel" receivers; Kodel Mfg. Co.
Monarch receiving set; Krasco Mfg. Co.
"Elkay" Super-Selector; Langbein & Kaufman.
"Liberty" Sealed Five receiver; Liberty Transformer Co., Inc.

BATTERIES

Storage "B" batteries; Kelman Electric Co.
"Kic-O" storage "B" batteries; Kimley Electric Co., Inc.
"Kic-O" "B" Multi-Power Unit; Kimley Electric Co., Inc.

"B" BATTERY ELIMINATORS

"Kellogg" Trans-B-Former; Kellogg Switchboard & Supply Co.

CRYSTAL DETECTORS

Atomite crystal; Keystone Products Co.
"Lego" Wonder fixed detector; Lego Corp.

BATTERY CHARGERS AND RECTIFIERS

"Kic-O" Rectifier; Kimley Electric Co., Inc.
"Kic-O" double potential charger; Kimley Electric Co., Inc.

POTENTIOMETERS

Mahogany potentiometer; King Quality Products, Inc.

A CONE TYPE LOUDSPEAKER

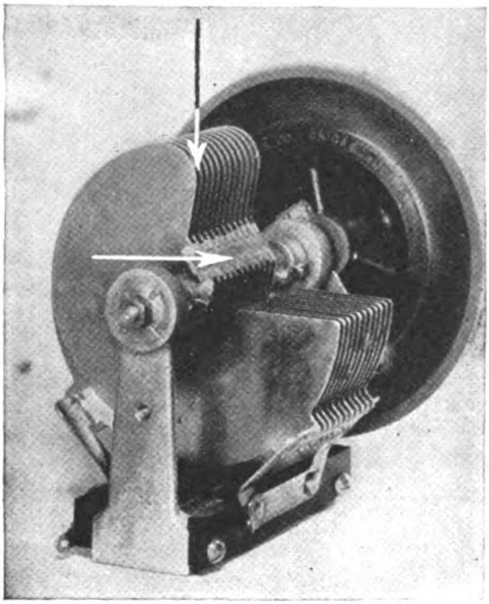
Name of instrument: Loudspeaker.

Description: A medium size loudspeaker which consists of a magnetic unit attached to the frame of the device with a moving element that actuates a small push rod attached to the center of a special paper cone. The outer edge of the cone is supported lightly but freely between two circular strips of felt held in a circular panel of metal. The appearance is very attractive.

Usage: With any radio receiving set as a reproducer.

Outstanding features: Tone quality. Volume. Neat appearance.

Maker: Crosley Radio Corp.



Unique design for a variable condenser that embodies cut-away plates that are securely soldered together.

AUDIO-FREQUENCY TRANSFORMERS

"Kellogg" audio-frequency transformer; Kellogg Switchboard & Supply Co.
Karas "Harmonik" audio-frequency transformers; Karas Electric Co.
Audio-frequency transformer; Killark Electric Mfg. Co.
"Liberty" audio-frequency transformer; Liberty Transformer Co., Inc.

JACKS

"Kellogg" jacks; Kellogg Switchboard & Supply Co.
Jacks; King Quality Products, Inc.
"Kings" double-circuit jack; Kings Mfg. Co., Inc.
Duo-stage jacks; Leich Electric Co.

DIALS

"Kellogg" bakelite dial; Kellogg Switchboard & Supply Co.
Knobs and dials; King Quality Products, Inc.
Knobs and dials; Kurz-Kasch Co.

A CABINET MADE ENTIRELY OF PANEL MATERIAL

Name of instrument: Radio cabinet.
Description: A complete cabinet that is supplied by the maker in knockdown form with screws, brackets, hinges and base. The front panel is of celeron and the sides, back and top are of vulcawood, which is vulcanized fibre covered with a thin sheet of bakelite. The vulcawood is finished with a mahogany grain, which is very attractive in appearance.
Usage: As a container for a radio receiving set.
Outstanding features: Simple to set up. Neat in appearance. Light weight.
Maker: Diamond State Fibre Co.

A NEW VARIABLE CONDENSER

Name of instrument: A variable condenser.
Description: Here is an instrument with a new method for mounting the plates. The shaft of the instrument which holds the rotor plates is mounted on a "U" shaped aluminum casting with suitable bearings at each end. Also mounted on this casting are two strips of insulating material which carry the metal form that holds the stator plates. All the plates are soldered together so that connection will be firm and conductivity will be high. The instrument is equipped with soldering lugs and a special vernier.
Usage: In any radio-frequency circuit for tuning.
Outstanding features: Efficiency. Novel design. Approximate straightline wavelength curve.
Maker: Kellogg Switchboard & Supply Co.

CABINETS

Radio cabinet; Kellogg Switchboard & Supply Co.

LOUDSPEAKERS

"Kellogg" Symphony Reproducer; Kellogg Switchboard & Supply Co.
K.-E. loudspeaker; Kirkman Engineering Corp.

HEADPHONES

"Kellogg" headset; Kellogg Switchboard & Supply Co.
Lark headphone; Leich Electric Co.

PHONE PLUGS

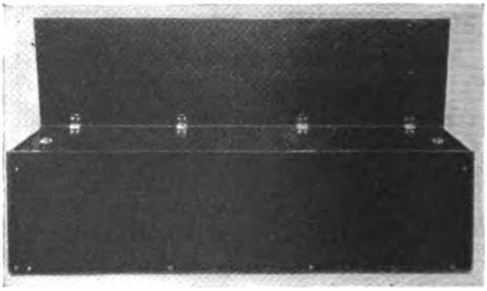
Snap plug, No. 501; Kellogg Switchboard & Supply Co.
Plug No. 502; Kellogg Switchboard & Supply Co.
Plug; King Quality Products, Inc.
Lark plug; Leich Electric Co.

RHEOSTATS

Rheostat; Kellogg Switchboard & Supply Co.
"Keystone" filament rheostat; Keystone Radio Co.
Mahogany rheostat; King Quality Products, Inc.

SWITCHES

Tuner switch; Kellogg Switchboard & Supply Co.
Back-mounting inductance switch; Keystone Radio Co.
Mahogany inductance switch; King Quality Products, Inc.



A complete cabinet supplied in knockdown form.

A FINE TRANSFORMER

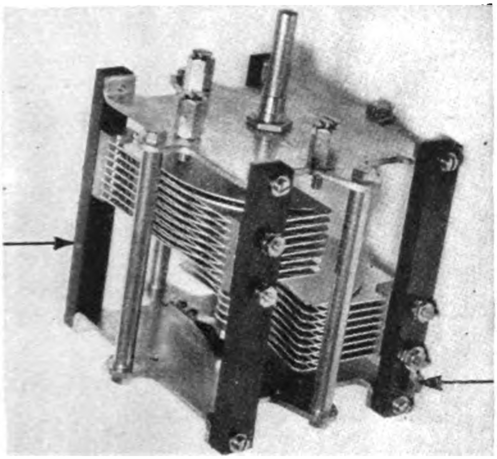
Name of instrument: Intermediate-frequency transformer.

Description: This new instrument may be used as a coupling unit in the intermediate stages of a superheterodyne receiver. The coils are wound on a special bobbin with a small amount of iron placed so that the resonance curve will just include the side bands necessary for complete reproduction. The terminals are brought out to soldering lugs mounted on a bakelite panel. The whole instrument is built up in a small aluminum case with a novel means for attaching in either of one or two positions—vertically or horizontally.

Usage: In a superheterodyne receiver as a coupling unit.

Outstanding features: High efficiency. Selectivity. Small size. Stable operation.

Maker: Silver-Marshall, Inc.



Radion separators are used on this condenser with soldering lugs for connections.

A NEW TRANSFORMER WITH SELF-SUPPORTED WINDING

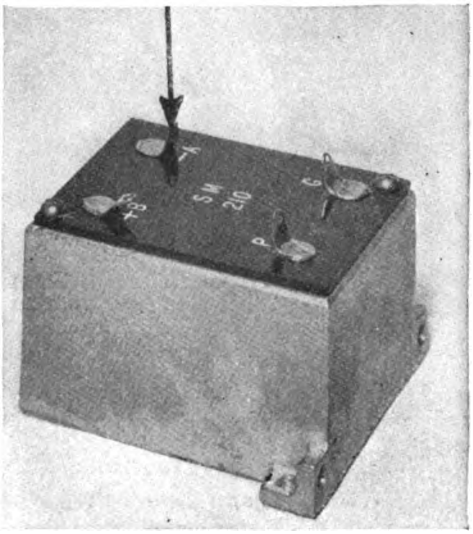
Name of instrument: Radio-frequency transformer.

Description: This instrument consists of two coils, a primary and a secondary which are wound in an octagonal form and fastened by means of two gummed strips of paper. The two coils are supported on two strips of bakelite with suitable brass angles for mounting on a baseboard or for attaching directly to a variable condenser.

Usage: In any radio-frequency circuit for coupling between stages.

Outstanding features: High efficiency. Low distributed capacity.

Maker: Eastern Coil Corp.



A transformer equipped with soldering lugs.

A DOUBLE TUNING UNIT

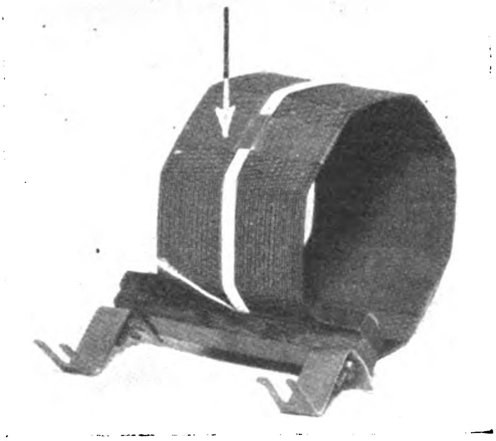
Name of instrument: A unit variable condenser.

Description: This instrument contains two variable condenser units mounted on a single shaft. The two units are placed diagonally in relation to the shaft. The end-plates are similar to the regular Cardwell construction except that the design is doubled up. Four rubber insulating segments are used; two to each unit. Both rotors are grounded on the same shaft and the two stators are separately insulated. All connections are brought out to soldering lugs.

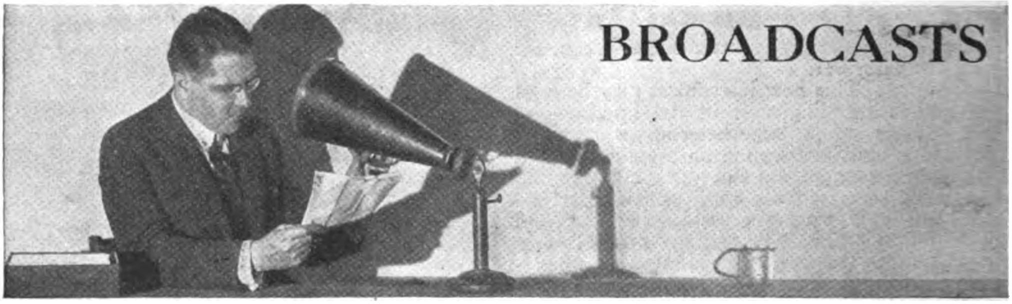
Usage: In any radio-frequency circuit for tuning.

Outstanding features: High efficiency. Compactness. Simplicity in tuning.

Maker: Allen D. Cardwell Mfg. Corp.



Coils supported with gummed strips.



CONDUCTED BY DAVID LAY

ITEMS *of general interest that you ought to know; bits of useful information that every radio fan ought to know.*

Inter-Continental Communication Between Amateurs

TWO-WAY daylight communication between Australia and England was established for the first time on May 2, 1925, between Mr. E. J. Simmonds (20D), the well-known amateur of Gerrard's Cross, Bucks, transmitting on a new wavelength of 20 meters, and Mr. H. Maclurcan of Sydney.

* * *

How Radio Is Growing

EXPORTS of radio apparatus increased from approximately $2,900,000 in 1922 to $3,500,000 in 1923 and to over $6,000,000 in 1924. Radio exports during the first months of this year have been more than twice those during the same period last year. Canada is our best customer, with Mexico second and Brazil third.

* * *

The Best U. S. Amateur Station

THE highest honor in amateur radio, the 1924 Hoover Cup, has been awarded to B. Molinari of 653 Union Street, San Francisco. This cup is given annually by Secretary Hoover to the operator of the best amateur radio station in the United States in which the bulk of the apparatus is the handiwork of the operator himself. The station for which the award is made, 6AWT, has been unusually efficient in communication with foreign countries; its signals have been reported by amateurs in Asia, Australia, South Sea Islands, Europe, Africa, South America, Central America and Danish America. 6AWT was one of seven stations selected to transmit press reports to Captain Donald B. MacMillan in the arctic. The station has also been in two-way communication with New Zealand and Australia. The station has the familiar Hartley circuit for the transmitter, which employs one 250-watt tube. The receiver is of the conventional amateur low-loss type, the tuning of which is accomplished by a glass insulated condenser across the low-loss secondary coil. The antenna is a semi-vertical parachute type, 15 feet long and 80 feet high at the free end. The counterpoise is a nine-wire fan-shaped area 40 feet in length.

* * *

A World Conference on Radio

A RADIO conference will be held at Washington, D. C. this September when the representatives of about fifty nations will assemble to discuss international problems in radio communication and broadcasting. The necessity for calling the International Radio Conference is due to the fact that the old regulations comprised in the London Convention of 1912 are inadequate to cope with communciation problems brought out by broadcasting and the modern radio apparatus. Originally, the London pact dealt with the shore to ship and ship to ship radio-telegraphy.

* * *

The Costs of Publicity by Radio

THE following rates for broadcasting have been established by the principal stations: New York, WEAF, $500 an hour; Philadelphia, WFI or WOO, $200 an hour; Pittsburgh, WCAE, $200; Washington, WCAP, $150; Buffalo, WGR, $200; Boston, WEEI, $250; Providence, WFAR, $250; Cleveland, WEAR, $150; Cincinnati, WSAI, $200; Detroit, WWJ, $200; Davenport, WOC, $150; Minneapolis, WCCO, $250. The gross charge an hour for one group of eleven stations is $2,600. Talks are limited to ten minutes and are assessed at half the hourly charge. Broadcasting music or entertainment for a half-hour is one-half the hourly charge, plus 25 percent.

* * *

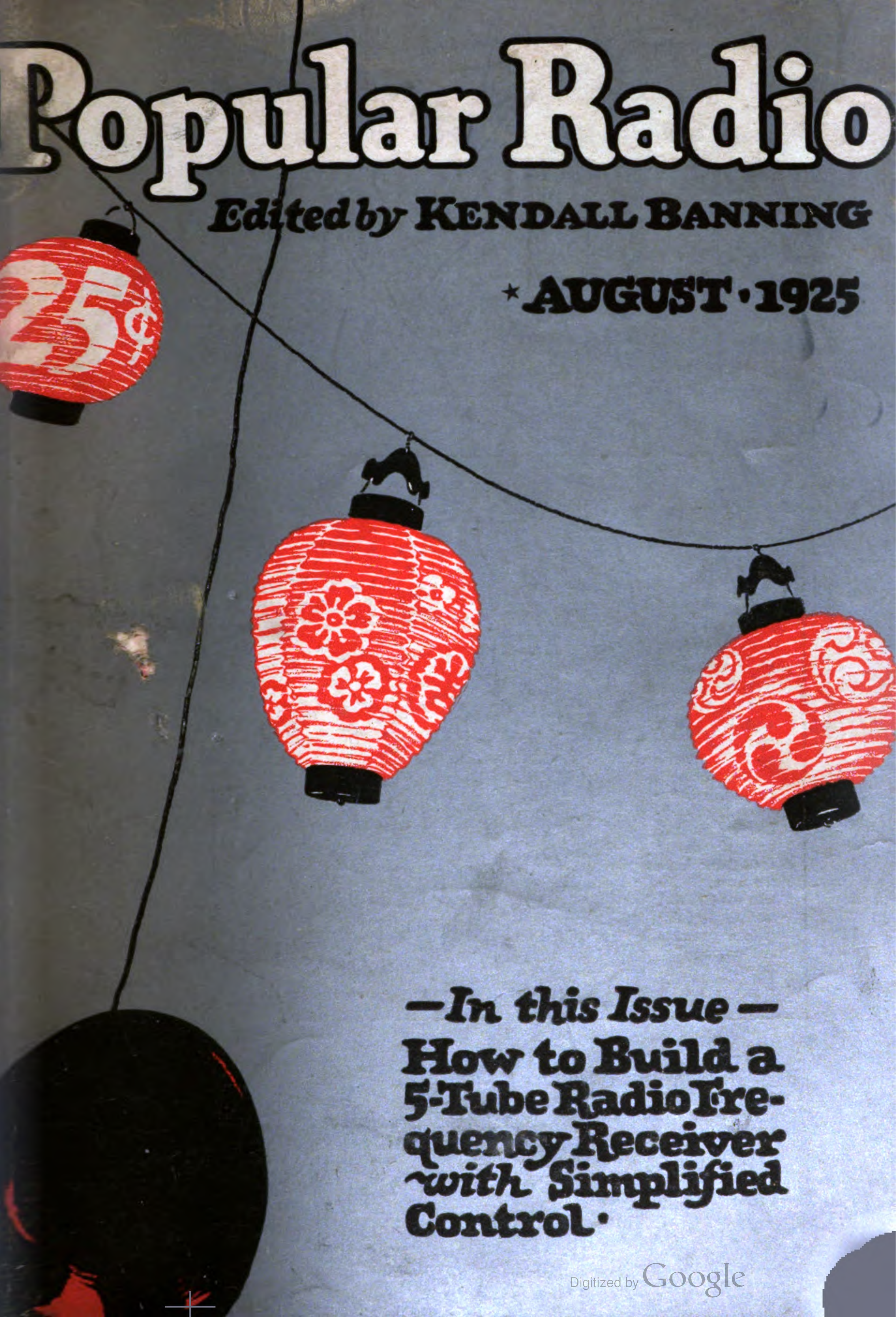
Sorbonnne Broadcasts Courses

THE success last year in broadcasting courses from the Sorbonne University in France was so great that the service is being extended this year, when four complete courses will be given by eminent French scholars. This is the first time in France that men of high academic standing have lectured regularly over the ether.

Popular Radio

Edited by KENDALL BANNING

★ AUGUST · 1925



—In this Issue—

How to Build a 5-Tube Radio Frequency Receiver —with Simplified Control·

It isn't a *genuine* UV-199 unless it's a *Radiotron*

The familiar names WD-11, WD-12, UV-199, UV-200 and UV-201-A rightfully belong to *Radiotrons* only. To be sure of *quality*, it is important to look carefully at the base of every tube you buy to see that it carries the name Radiotron and the RCA mark as proof that it is a *genuine* Radiotron.

Radio Corporation of America

Chicago New York San Francisco

RCA

Radiotron

AN RCA PRODUCT

Brandes

Listen for the low tones; listen for the high tones. Suddenly you'll realize how much *more* you hear through a Brandes. New rounded fullness in the low register—new clarified lightness in the high.

It took the Brandes Laboratories two years to develop this speaker. Two years of earnest research which are now rewarded by the supreme quality of their product. And the horn has grace and simple beauty. It is antique bronze in finish—but gold in *tone!*

The new Brandes Speaker (Type H) may well be the standard by which all others can be judged. And this is merely one way of saying, hear them all before you make your choice.

Price $18

Slightly more west of the Rockies and in Canada

© Copyrighted by C. Brandes, Inc., 1925

POPULAR RADIO

EDITED *by* KENDALL BANNING

CONTENTS *for* AUGUST, 1925

(*Cover design by Frank B. Masters*)

VOLUME VIII NUMBER 2

An Unusual Automobile "Extension" for Broadcasting............FRONTISPIECE
Riding to Riches by Radio..................*Ralph E. Renaud*......*Page* 99
Part I
"Motion Pictures" by Ether Waves............*Charles Allen Herndon*...... 107
Men Who Made Radio... 114
Eighth Installment
How to Get the Most Out of Your Ready-made Receiver..........................*S. Gordon Taylor*.......... 116
No. 7: The Grebe Synchrophase
A New Type of Hornless Loudspeaker.........*W. T. Meenam*............. 128
A Mobile Radio Relay Station...............*David Lay*................ 130
How to Build a 5-Tube Radio Frequency Set with Simplified Control.......................*Albert G. Craig*............ 136
"What Set Shall I Buy?".. 150
Important Trifles in Radio.................*Raymond Francis Yates*..... 154
The Grid-leak
The Atom...................................*William Bragg*............. 159
Article No. 1

DEPARTMENTS

What Readers Ask...........................*Laurence M. Cockaday*...... 164
In the World's Laboratories................*E. E. Free*................ 168
Trouble Shooting...........................*S. Gordon Taylor*.......... 176
The Broadcast Listener.....................*Raymond Francis Yates*..... 180
With the Inventors.........................*William G. H. Finch*........ 184
Broadcasts.................................*David Lay*................ 188
What's New in Radio Apparatus..............*The Technical Staff*......... 191
Hints for Amateurs.........................*Albert G. Craig*............ 195

VOLUME VIII AUGUST, 1925 NUMBER 2

Published monthly by Popular Radio, Inc., 627 West 43rd St., New York, N. Y., telephone number, Chickering 1906; Douglas H. Cooke, President and Treasurer; Kendall Banning, Vice-President; Laurence M. Cockaday, Secretary; Joseph T. Cooney, Asst. Treasurer. Price 25 cents a copy; subscription $3.00 a year in the U. S., Canada and all countries within the domestic postal zone; elsewhere $3.50 a year, payable in advance. The International News Company, Ltd., No. 5 Bream's Bldg., London, E. C. 4, sole distributors in England. Entered as second class matter April 7, 1922, at the Post Office at New York, N. Y., under the act of March 3, 1879. Copyright, 1925, and title registered as a trade-mark by Popular Radio, Inc. Copyright in Great Britain by Popular Radio, Inc. 6 Henrietta St., Covent Garden, W. C., London, England.

Printed in U. S A.

LAURENCE M. COCKADAY, *Technical Editor*
E. E. FREE, Ph.D., *Contributing Editor* JOHN V. L. HOGAN, *Contributing Editor*

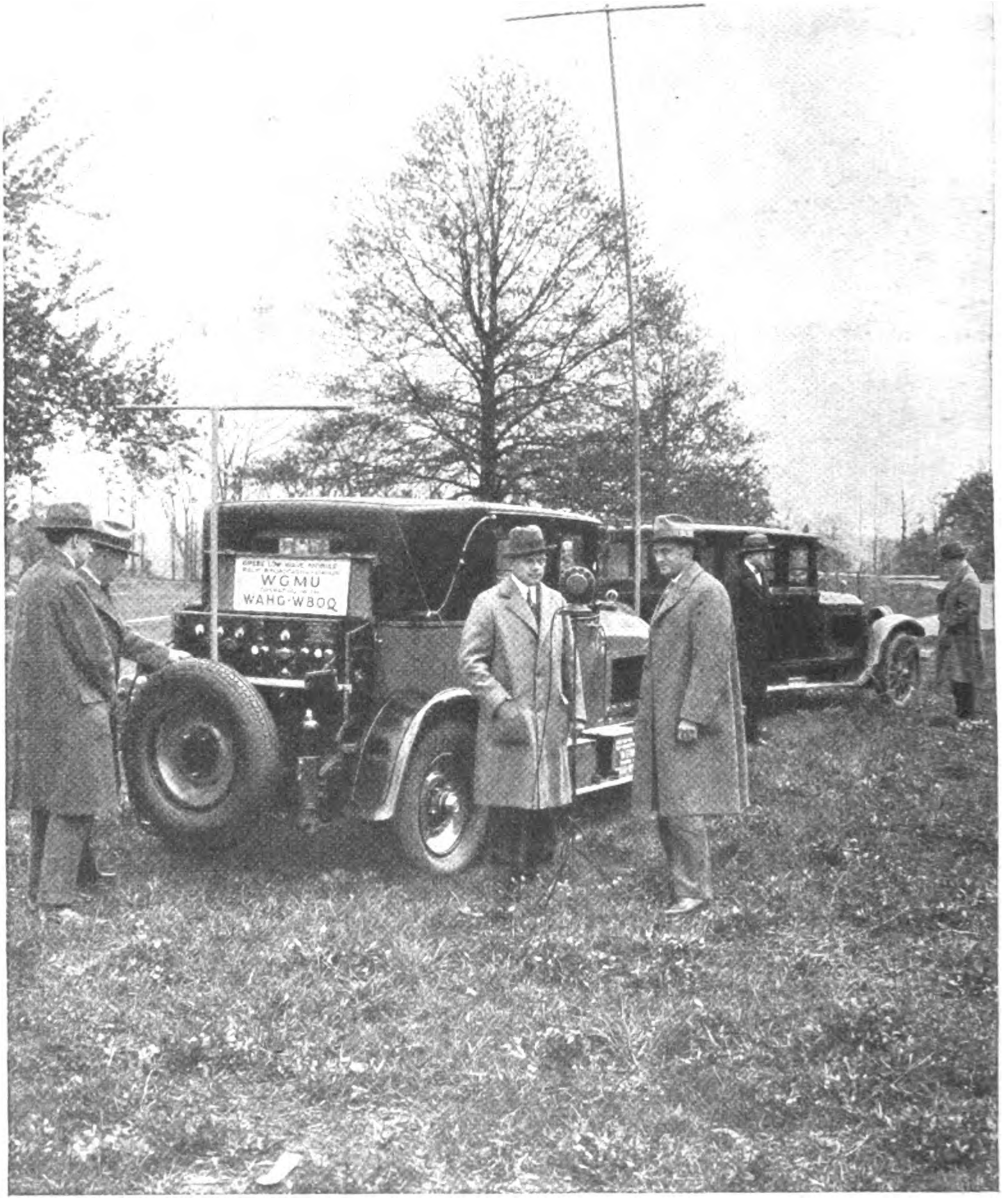
For advertising rates address
E. R. CROWE & COMPANY INC.
New York: 25 Vanderbilt Avenue Chicago: 225 North Michigan Avenue

POPULAR RADIO is a medium of expression of the skill of the radio amateur

"I read POPULAR RADIO *often and with great enjoyment. I find it an excellent expression of the ingenuity and skill of the amateurs who have done so much to advance the radio art."*

EFW Alexanderson

CHIEF CONSULTING ENGINEER,
RADIO CORPORATION OF AMERICA



From a photograph made for POPULAR RADIO

An Unusual Automobile "Extension" for Broadcasting

THE *use of the short-wave transmitter installed on an automobile for relaying events in the field back to the main broadcasting station for ultimate re-transmission on a regular wavelength is a feature that will do much to extend the facilities for broadcasting. In this picture, Mr. Al Grebe is shown demonstrating such an installation to the engineering staff of* POPULAR RADIO. (*See page 130.*)

Popular Radio

VOLUME VIII AUGUST, 1925 NUMBER 2

Riding to Riches by Radio

PART I

Stock in some radio enterprises is sound and is destined to increase in value; stock in other radio concerns is worthless. As a part of its service to its readers, POPULAR RADIO *points out, in this series of two articles, what the difference between the two really is—and how to find it before you invest. The author of this article is neither an investment expert nor a radio shark. He is merely an inquiring reporter in a comparatively new field. And as such he desires to hold up a not too solemn finger for the benefit of those who have not provided themselves with facts.*

By RALPH E. RENAUD

IN all the past twelve thousand years of civilization, commercially considered, there has been nothing quite so startling as the growth of the radio industry.

Five years ago radio telephony, as it is understood today, wasn't a business at all. It was a mere scientific prospectus.

Last year radio concerns took in a million dollars a day.

Late in 1920 Westinghouse erected a broadcasting station. Since then the yearly figures of sales growth read like an exercise in geometrical progression: 1920, $2,000,000; 1921, $5,000,000; 1922, $60,000,000; 1923, $120,000,000; 1924, $350,000,000. Nothing like that had ever been heard of before. It made the statisticians gasp. The motor industry, now the first in the United States, turned over $3,168,588,146 last year and hatched out 3,617,602 cars. But it had been incubating thirty years. Moving pictures also reeled off their profits into astronomical figures, but the days of the infant nickelodeon industry were long ago. Within the life of a good, healthy lawsuit radio has become the world's foremost indoor sport. And in its present mood, be it at Boyle's Thirty Acres, Coogan's Bluff, or fishing for DX right beside the old fireside, the world will pay anything for its sport.

Just what is the commodity for which all this money is being turned loose? In essence it is energy in the smallest conceivable quantities, electromagnetic waves so weak they have to be measured by the microampere. If all the energy picked up last night by all the receiving sets of the world were concentrated into a single impulse it wouldn't drive an electric locomotive from the Pennsylvania Terminal to Manhattan Transfer. It wouldn't even start it.

Yet the United States alone paid a million dollars a day for its share of that infinitesimal fly-power!

By the time we began to put up our

new calendars radio sales had already doubled those of kodak and sporting goods. The industry had nudged into a position beside shipbuilding, chemicals and leather. Naturally the inevitable consequences of such increase had not escaped the attention of the public. And, lest this introduction to a discussion of radio stocks be dismissed as a roseate come-on, let us add right here that the public has not escaped the consequences.

The first radio stocks lay fallow on the market. A few discerning souls who had sense enough to buy the right ones are now commuting in airplanes. Then a prize fight, with its clanging gong of destiny, was broadcast, and sets, home-made or shop-sold, began to invade the hitherto sacred privacy of the American home. Every other set-owner whispered to himself, "Say, this is going to be good! There ought to be money in this!" He repeated it, more confidently to his friends and neighbors. It was perfectly apparent that to the manufacturers the receiving set was proving an Aladdin's lamp. Pretty soon there were thousands who wanted to horn in on the profits.

The tom-toms were already beating for them. The witch-doctors had begun the ghost-dance and the snake-oil was bottled. About two years ago radio stocks blossomed like dandelions after a spring rain. Then they began to act very much as the airplane stocks are acting today. In other words, they started to airplane. Paper millions in stocks were floated, some good, mostly bad. In much of the literature there was the rankest sort of misrepresentation or, what amounts to the same thing, unwarranted enthusiasm. The majority of the hundred or so radio companies which have offered stock to the public in the past few years have not only retired from business but are so poorly (or well) remembered that there is no bid for their stocks.

Spurlos versenkt!

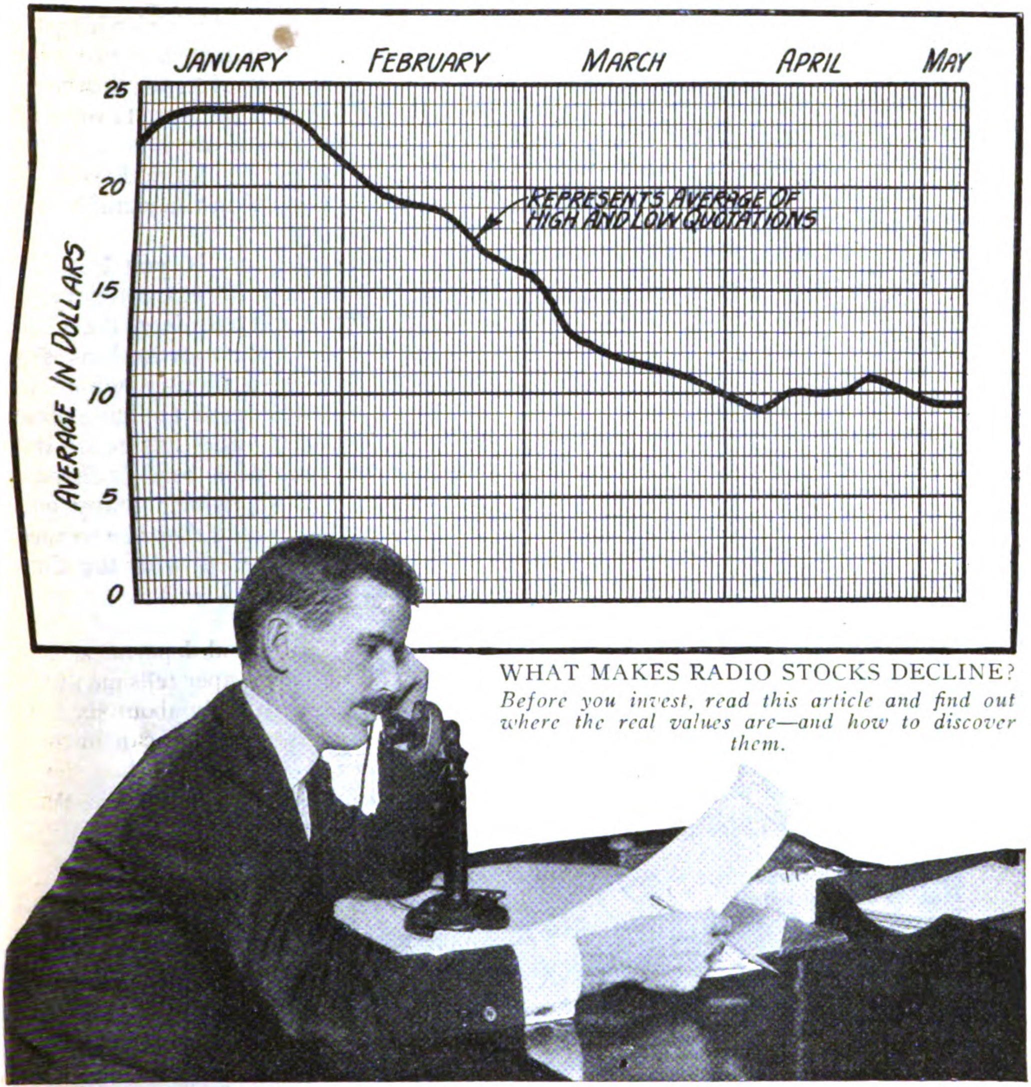
Still, it is quite possible to find radio and affiliated stocks. It would not be overstating the case to say the woods are full of them. There are now approximately fifty-one radio, communication, and electrical equipment stocks which would be recognized with varying degrees of cordiality by a respectable broker. These range from the patrician General Electric, batting around 300, to Jones Manufacturing, at a dollar and a quarter.

Of the actual radio stocks, there are not more than a dozen listed, only one (Radio Corporation of America) being listed on the Stock Exchange. The unlisted market offers another dozen or so which can't or won't meet the listing requirements. These are the "over the counter stocks." Beyond and outside even the unlisted market a not too vigorous search will uncover additional alleged radio stocks. It is there that the bargains can be picked up for twenty-five or thirty cents. But even Woolworth isn't dealing in these.

The head of the financial department of a great New York newspaper tells me that in his opinion there are only about six of the strictly radio stocks which can justly be called good. Probably less than this number have real investment merit. As he phrased it, "The others are either a tremendous speculation or rank swindles." Perhaps, after we examine the patent situation, as we shall, we may conclude he is an optimist, at that.

What, then, is the matter with the radio stocks? All have beautifully engraved certificates, and most have acquired pleasant salesmen who do not hesitate to say a few kind and tactful words about them. To find at least part of the answer, suppose we select a few of the companies and scrutinize them a little more closely than their salesmen would care to do.

Exhibit A must be exhumed from the graveyard of radio flops—companies, so to speak, which have passed into the great beyond where there are no margins or giving of margins. But it was a whiz-bang of a little concern while it lasted. It had a name which strongly suggested the General Electric Company. But the resemblance ended with the nomenclature. There were also some honored names



WHAT MAKES RADIO STOCKS DECLINE?

Before you invest, read this article and find out where the real values are—and how to discover them.

Brown Bros.

among the Board of Directors—sons of presidents, and things like that. But it is only fair to add that a number of these resigned as soon as they heard they were elected, and others withdrew while the going was good.

Never at any time in its career did the corporation have any capital whatsoever. But it promptly broke out into a capital stock issue of $5,000,000 worth of shares—150.000 shares of 8 percent preferred stock at a par value of $10 and 3,500,000 shares of common at a dollar. As stated, the company had no capital, as none of the amateur financiers who organized it really yearned to put any money into it. But it would be unjust to say it had no assets. It possessed two ringing slogans, "Strike While the Iron is Hot," and "Ride to Riches with Radio."

At an early stage of the proceedings a George Randolph Chesterish promoter, well upholstered in the customary fur coat, arrived on the scene like a fairy godmother, informed all and several to quit worrying, and announced that he proposed to take over the entire direction of affairs. The hypnotized officers seem to have let him get away with it. Thereupon it was broadcast that negotiations were under way to market the whole manufacturing output of several going concerns. They put it just that way, oh, so cagily!—"negotiations were under way." But somebody neglected to sign any contracts. The sales catalog showed impressive half-tones of factories at Woodside, N. J., Newark, N. J., and Kearney, N. J. The catalog did not assert outright that these busy factories were the property of the corporation. Neither did it state the truth that the only connection between corporation and factories was an occasional small order. But the general impression left on the reader was to the effect that these pictured factories were merely small Jersey samples of numberless thriving plants controlled by the company throughout North America and contiguous territory.

The catalog said, nay, it almost sang, that:

> "This corporation
> Manufactures its own goods.
> Assembles its own parts.
> Retails direct to the public.
> Wholesales direct to the jobber.
> Eliminates the middleman.
> Sells for cash in advance only.
> Has no funded debt.
> Has no notes, no bonds outstanding.
> Has no dead assets.
> Can therefore realize practically everything instantaneously for cash."

At the time the public was thus invited to "Ride to Riches with Radio" this company had manufactured nothing, assembled virtually nothing, and sold nothing. It had become nothing but a scheme to peddle stock. Of course, they didn't do it quite so successfully as Jimmy Elliott, of Phonofilm fame, and his high-powered band of diplomaed go-getters. They had no picture of President Coolidge to aid them. But they did very well—so well, indeed, that in a little while the entire Board of Directors decided to "Strike While the Iron is Hot" and quit, leaving the promoter-sales-manager in charge of a company without officers, a sales organization and a flossy name. The stockholders, of course, were left clutching the bag. As a matter of fact, it is of record in this case that long after an agreement had been made under pressure to cease all stock sales, the sales of stock nevertheless continued. But let us leave Exhibit A before we get tangled in the ramifications of grand larceny.

The second case, or, if you like, Exhibit B, falls into a different category. It is dryer reading and requires the ability to draw commonsense conclusions from elementary figures—a faculty which few purchasers of stock seem to have developed. This company also has some well-known names back of it and is listed at present on the Curb, where many good little stocks go the minute they are weaned.

The balance sheet filed with the Curb last September shows:

ASSETS

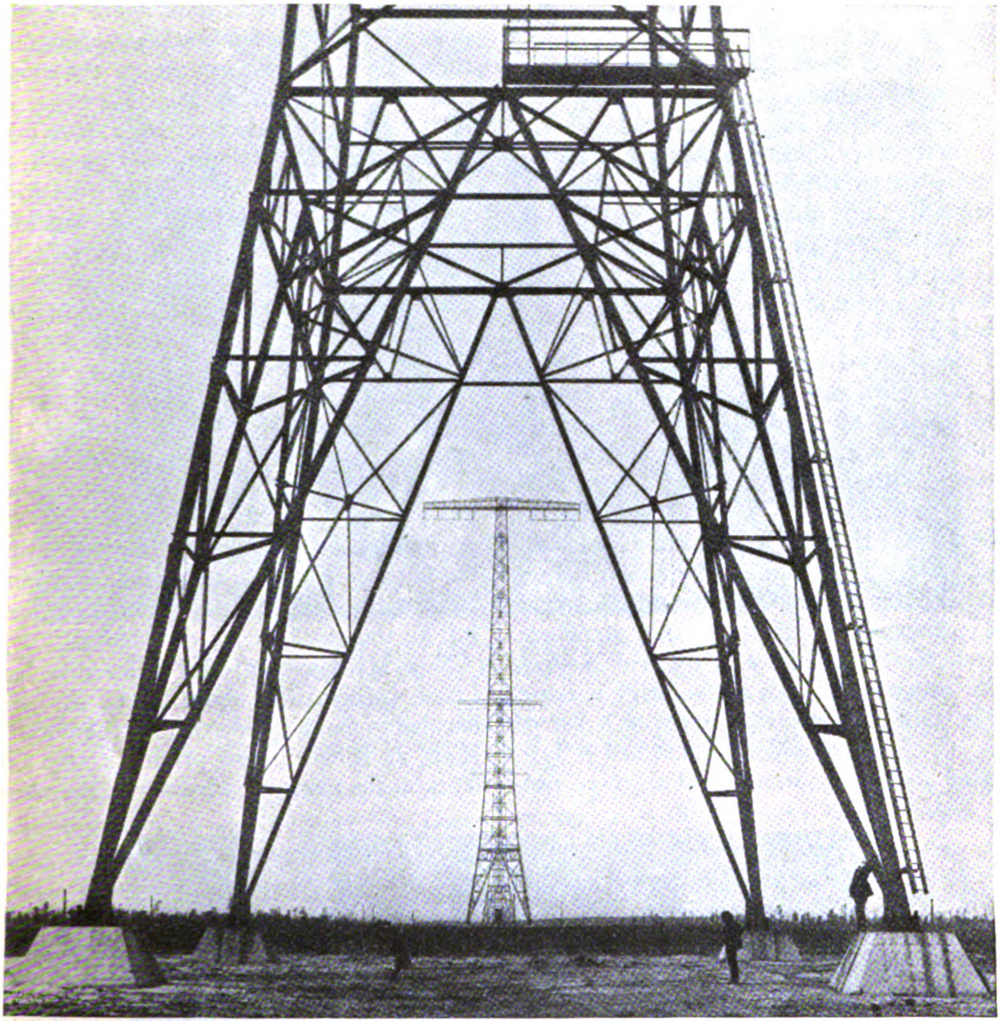
Cash on hand, or subject to our withdrawal	$38,000.00
Accounts receivable	25,000.00
Advances to subsidiary companies	12,000.00
Patents	1,250,000.00
Investments	
Stock in subsidiary companies (without goodwill valuation)	38,352.06
Tools, drawings, patterns (estimated)	50,000.00
	$1,413,352.06

LIABILITIES

Accounts payable (Accrued organization expenses)	$5,000.00
Capital stock (Authorized 250,000 shares, no par value)	1,408,352.00
	$1,413,352.06

Particular attention is hereby directed to that item of "Patents" set down as $1,250,000.00. There really are some patents, beside an Armstrong license, consisting of several radio and automotive devices. No one can say they are not worth that much and anybody can say they are. But that item is certainly called on to do a man-sized job of balancing. Incidentally, the factory of this concern turned out, on investigation, to occupy a space of 100 by 100 feet in a West Side loft building. Admission was refused. Apparently there were about twenty people at work. The set produced is said to be a good one.

Now then, let us look at another bal-



Radio Corporation of America

PROPERTY VALUES PLUS MONOPOLY RIGHTS AFFECT STOCK HOLDINGS

The value of holdings in the Radio Corporation of America partly rests upon its monopoly of transatlantic commercial radio communication, backed by costly equipment. This picture shows some of the radio towers on its Long Island plant.

ance sheet issued by the same concern and submitted to the public. This one is prefaced by an inconspicuous note and is as follows:

ASSETS

After giving effect to present financing

Cash on hand	$591,184.91
Accounts receivable	1,960.94
Inventories	22,840.19
Tool equipment	24,520.03
Furniture and fixtures	162.00
Patents, development and patent rights	920,630.28
Deferred charges	1,870.00
Organization expenses	9,000.00
Total assets	$1,572,168.35

LIABILITIES

Accounts payable and trade acceptances	$9,668.35
Net worth of capital stock	1,562,500.00
	$1,572,168.35

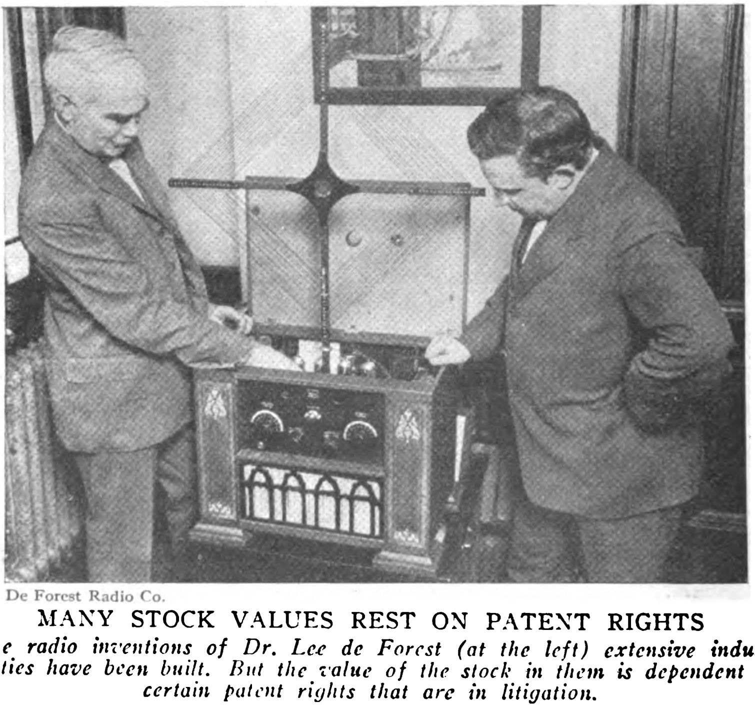
If this balance sheet be compared with the first the patent item seems to have shrunk, due, no doubt, to the lapse of time—and the item of cash on hand to have swelled enormously, from $38,000, as a matter of fact, to $591,184.91. But there is no real discrepancy. The little note at the beginning of the second statement, "After giving effect to present financing," explains everything. You see, the cash is only on hand "after giving effect to present financing," or, to put it a bit more crudely, when the stock is sold.

Sometimes these unobtrusive prefatory notes are overlooked by hurried investors, though they are indulged in by the Street's "best people." Incidentally, the stock of this concern at this writing is worth approximately a fifth of what it was offered for—or rather, it is quoted for a fifth of what it was offered for.

The third case shows what may happen to holders of a premier radio stock, admittedly sound, who fail to watch their step. There are two villains to this piece—Mr. Ginsberg and Mr. Hassenpfeffer, let us call them, chiefly because these appellations are so unlike their own names. At the time Radio Corporation of America changed its capital stock structure, and offered one share of the new A stock for every five shares of the original issue, Mr. Ginsberg, having procured a list of R. C. A. stockholders, conceived a brilliant idea. He circularized all these people, offering to act as their agent for purposes of transfer and hinting at some four times their present return on the stock. His plan was a simple one. He proposed to put up each share as margin, thus purchasing additional shares, and gamble on the stock going up, which it did, furiously.

But our Mr. Ginsberg, unfortunately, was not like Cæsar's wife. In fact, his reputation was so little above suspicion that legitimate brokers could scent him from afar. So it was necessary for Mr. Ginsberg to transact his business with a broker of standing similar to his own, a Mr. Hassenpfeffer, already mentioned as among those present. The Ginsberg circular appeal had brought out a considerable amount of the stock which he deposited with Mr. Hassenpfeffer, directing the latter to proceed as outlined above and incidentally slipping to the extent of placing all the stock in his own name.

Now Mr. Hassenpfeffer believed he had inside information about R. C. A. He decided to gamble for a drop in the bucketshop, as it were, and promptly sold the stock at the market. Meanwhile the stock



De Forest Radio Co.

MANY STOCK VALUES REST ON PATENT RIGHTS

On the radio inventions of Dr. Lee de Forest (at the left) extensive industrial properties have been built. But the value of the stock in them is dependent upon certain patent rights that are in litigation.

Kadel & Herbert

AN INVENTOR WHOSE PATENTS HAVE INVOLVED LEGAL COMPLICATIONS THAT BEAR UPON STOCK VALUES

Dr. Marius C. A. Latour (seated), a noted French inventor, after assigning various patent rights and licenses to radio corporations, became engaged in litigation when it developed that the Hazeltine Corporation had bought control of the Latour Corporation.

continued to rise steadily, and Mr. Ginsberg, the optimist, cheerfully licked his lips. When the market price had sky-rocketed to an altitude at which he felt he could no longer afford to wait he called on Mr. Hassenpfeffer for his profits. Mr. Hassenpfeffer blandly informed him that there weren't any, adding as an afterthought, that there wasn't even any stock. Well, well! You can readily imagine how embarrassing this proved to poor Mr. Ginsberg. The merest prod of the toe revealed that Mr. Hassenpfeffer was financially flat on his back, and Mr. Ginsberg's clients were clamoring for a settlement.

To one of these, whose loss was a small matter of $4,000 and whose real name isn't Mrs. Gull, he wrote consolingly, thus:

"Dear Mrs. Gull:

"The house with which we were carrying radio stock has not rendered us an accounting yet, and it seems as if they are in some sort of difficulty and we are trying to adjust these matters in order to get the money coming to you from the sale of the stock.

"We have taken the matter up with the authorities here who have worked with us on this account and expect to have results after Thursday, the day on which the matter comes up for discussion.

"Will you kindly have a little patience until that time?

"Very truly yours,
"S. L. Y. GINSBERG."

There was a certain modicum of truth in this letter. The house with which Mr. Ginsberg was carrying the stock was, beyond a doubt, "in some sort of difficulty." And he had indeed taken the matter up with the authorities, or *vice versa*, as the case may be. He has been compelled by subpœna from the Attorney General's office to appear and show cause why he should not be prosecuted under the Martin Act. Will the stockholders get their money back? . . . Yes, we have no bananas.

These examples explain the vicissitudes of particular stocks. But to explain what has happened to all the radio stocks, without exception, the state of the industry itself must be examined.

In many ways last year radio was under forced draught. It was a political year, and politics called on the art of broadcasting for the first time. Many people believed that it was necessary to own a receiving set to follow the campaign properly. Then came the Democratic convention in Madison Square Garden, with its thrilling story of embattled giants and howling mobs vibrating day and night across the ether for almost three weeks. The stentorian lungs of Governor Brandon booming into the microphone that "Ala-baaaaam-a casts twenty-four votes for Oscar W. Underwood!" did a million times more to advertise radio than all its paid press agents. The public went mad-dog on radio and remained so up to and including December 25.

Then the overburdened Christmas tree broke down.

It must have been apparent to all who read the advertisements in the daily papers during the past six months that something untoward was happening in the radio industry. Evidence accumulated showing that a good many of the twenty-one hundred manufacturers were in trouble. Department stores burst into a rash of double-page announcements that they were prepared to sell standard sets for half price. Prices were slashed everywhere, in one way or another. General Harbord, at the last meeting of the Radio Corporation stockholders, estimated that 325,000 receiving sets had been thrown on the market.

So, it is clear today that radio is suffering from colic—too many green apples. The industry, stimulated by the fiercest production rivalry of record, turned out a bumper crop of receiving sets. The public was asked to eat them green. And the public process of digestion simply broke down. This painful reaction occurred just when radio was experiencing its natural seasonal decline, unchecked this year by the stimulating tonic of politics. For it is only wisdom to admit that interest in radio is as seasonal as it is in motoring or golf.

The stock market is a prosaic place, but all these conditions were promptly reflected therein. The stock market has a way of being intolerably prompt. Radio stocks began to slide rapidly down hill. In many cases, of course, it was merely a case of water seeking its own level. Speculators operating among the radios on margin were wiped out like so many chalk marks. It is said that at the time the slide began there had been at least one share of radio stock sold for every receiving set used in the United States. That would mean about 3,000,000 shares. During the period of inflation the increase had been extraordinary, in one case a gain of 400 percent. But proportionate to the time involved the drop was even more impressive. One stock lost 80 percent.

Julius G. Berens, in a compilation of twenty radio stocks, showed that the difference between the high of 1925 and the low toward the end of May was something like $82,775,000 out of a total market value of $179,664,000.

Yet it isn't all unhealthy, this process of deflation. Applied to the radio industry as a whole, and especially to its mirror in the stock market, these timely reducing exercises will develop a sounder and less flabby body. Only the fittest in the field will survive. The "gyps" will be pinched out. There will be bankruptcies, liquidation and receiverships. This is painful to all concerned. But perhaps the most excruciating, because undeserved agony, will be experienced by those who have never learned to distinguish between an investment and a contribution to charity

But how *does* one learn?

The next installment of this article will tell how to distinguish between good radio stocks and poor ones. It will appear in POPULAR RADIO *next month—September.*

HOW THE MOVING IMAGE APPEARS ON THE SCREEN

The pictures projected upon the screen by the "teloramaphone," in their present early state of development, show figures in silhouette only.

"Motion Pictures" by Ether Waves

The home radio movie has arrived. We have now reason to hope that we will eventually sit at home and watch the world series exactly as it is played and hear the umpire and the crowd at the same time. People in the most isolated sections of the country will attend distant Fourth of July celebrations, or perhaps, the next presidential inauguration by radio, and see and hear more of it than if they were in the crowd in front of the speaker's stand."—C. Francis Jenkins.

By CHARLES ALLEN HERNDON

C*OMING events cast their shadows before."*

As this is written, I have just come from a shadow-show in the Washington suburban home of C. Francis Jenkins.

The figure that produced the shadows was on a motion picture film being projected in the inventor's laboratory in Washington. It was separated from the screen by six miles of city and suburban streets and houses.

While the little crowd of neighbors and friends watched a small screen which formed a panel in the receiving set, there suddenly appeared on it the silhouetted figure of a girl. There was no scenery. The details of the dancing figure were not shown. But the shadow-like figure moved—it danced. And those who were present seemed to realize that, simple silhouette though it was, it was really dancing at the wedding of the motion pictures with radio.

When you think of the great super-feature motion picture play with its thousands of actors, its elaborate sets and its faithful reproduction of infinite minute details, this simple silhouette of a lone dancer may seem disappointingly crude. But even the wonderful motion picture industry had its crude beginnings.

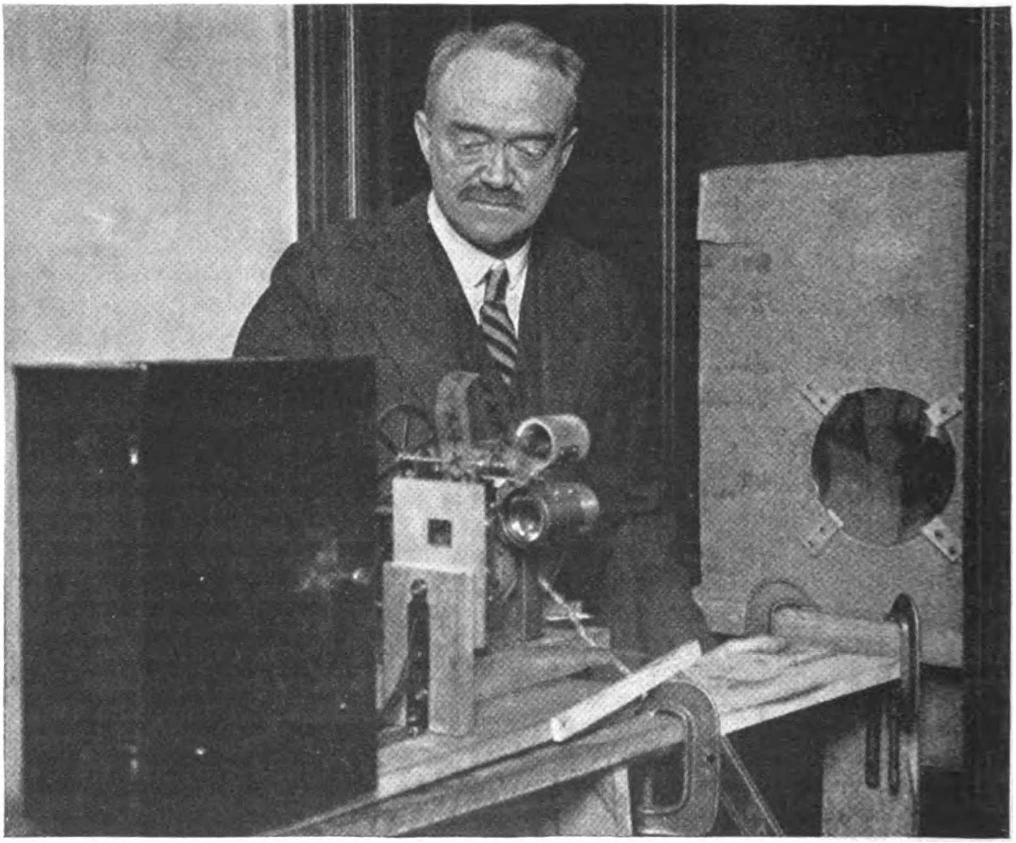
In fact, the first feature film (which was presented to the public at Richmond, Ind., in 1894, and projected from the first machine of the type now in general use throughout the world) also merely depicted a solitary dancer. That dancer of 1894 was probably directly responsible for the subject of the radio movie of 1925; for the inventor who made that first machine and gave that first motion picture performance was this same C.

Francis Jenkins, who has now married the movie to radio.

Ever since then, he has devoted much of his time to inventing improvements on motion picture apparatus, including a slow-motion picture camera which takes 4,000 pictures a second. When the radio came in, however, he turned enthusiastically to the problem of sending and receiving pictures by wireless. He worked out the only system so far devised for sending typewritten and other matter and receiving similar messages on the same machine at the same time and also the only system of sending radio pictures from a flat surface to a flat surface.

But ever since Mr. Jenkins succeeded in sending such still pictures in this country, or since M. Edouard Belin in France or Prof. Arthur Korn in Germany performed similar experiments abroad, imaginative persons have confidently predicted that some day motion pictures would be sent by radio. As the motion picture is just a series of still pictures showing successive phases of action, it did not take much mental daring to make the forecast. The prophets were, however, rather vague as to just when this newest wonder would start or just how it could be brought about.

It is easier said than done. In order to



From a photograph made for POPULAR RADIO

THE FIRST MOTION PICTURE MACHINE

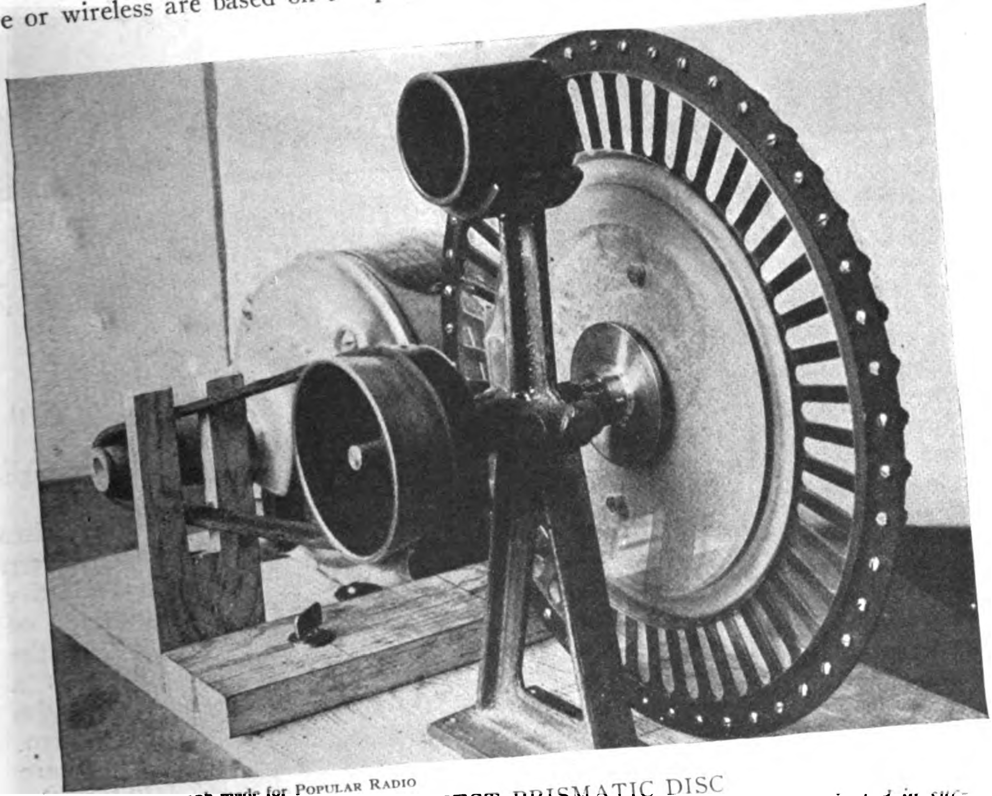
This machine—operated by its inventor, C. F. Jenkins— uses standard motion picture films. The changing pictures on the film are imaged on the flat surface of the large plano-convex lens at the right, which is held in place in the screen by four pieces of wood. The lens which projects these pictures onto the larger lens is the lower one of the two small cylinders directly in front of the inventor.

obtain the illusion of motion in a motion picture at least sixteen complete pictures must be projected every second. In order to send one complete still picture giving fine details by radio, it requires about six minutes by the best system now in use.

Six minutes seems short when you remember that the radio picture is knocked down, as it were, and then built up piece by piece at the receiving station. The lights and shades which make up the photograph must be translated into variations in an electric current, which in turn must be translated back again into lights and shades which make up the reproduction at the receiving end.

All systems of sending pictures by wire or wireless are based on the photo-electric or light sensitive cell. That is, certain substances used in these cells have the peculiar property of permitting current to flow through them more readily when they are illuminated than when they are in the dark. They act as electric valves. By simply varying the amount of light that reaches them, the current passing through them can be varied correspondingly.

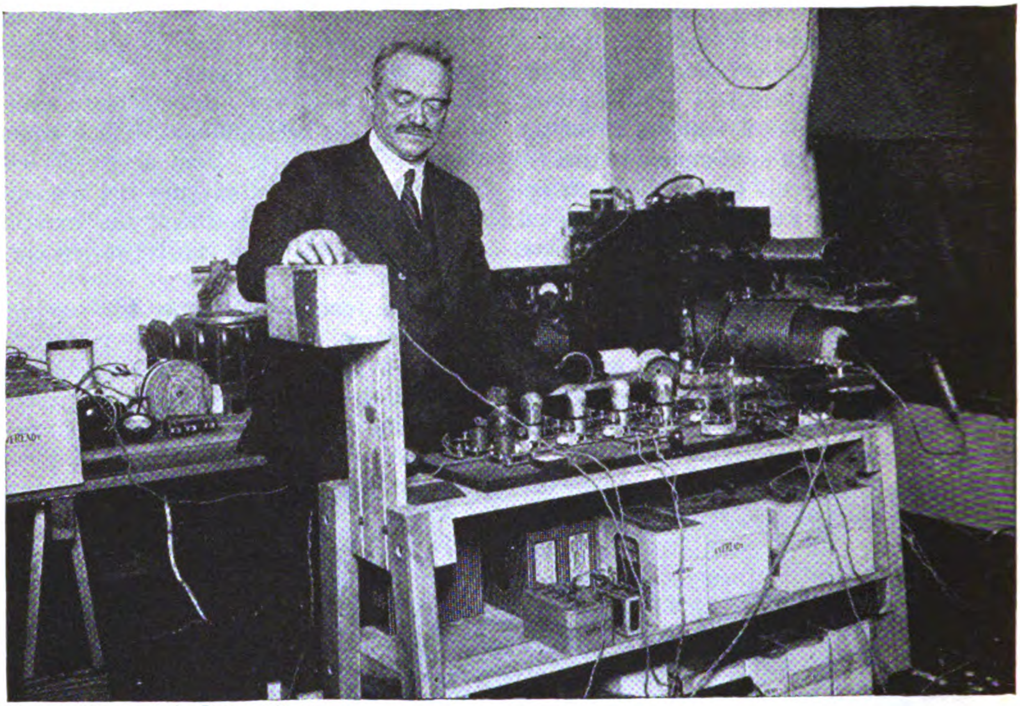
In the Jenkins apparatus for sending still pictures, for instance, the picture is placed in an ordinary stereopticon or magic lantern and its image is projected across the room so that one tiny corner of it strikes a hole in a box in which there is a thallium sulphide cell. If that tiny corner happens to be a shaded portion



From a photograph made for POPULAR RADIO

THE LATEST PRISMATIC DISC

The source of light is located in the round black box. This light is projected in succession by each lens located in the small openings around the periphery of the wheel onto a small motion picture screen. As the lenses rotate, each draws a line of light across the screen, but as the circular prism behind the lenses is constantly changing the angle between its faces, each line is drawn just under the last one until the picture is complete. Thus, for each revolution of the prismatic wheel one picture is placed upon the screen and as the disc rotates at a speed of 900 times each minute there are fifteen pictures a second produced on the screen.



From a picture made for POPULAR RADIO

THE RADIO UNITS FOR THE MOVING PICTURE TRANSMITTER

The inventor has his hand placed on the small square box that contains the light-sensitive cell which converts the pictures into electrical impulses for transmission by radio. This, when attached to the apparatus shown on page 108, will transmit moving picture films and when used in conjunction with the apparatus on page 112 will transmit pictures of living subjects.

of the picture, only a weak current can pass through the cell. If that little piece of the image represents a light part of the picture, a strong current is permitted to pass through the cell.

In order to send a picture, each part of it must be brought in front of the light cell, so that the variations in its lights and shades will produce corresponding variations in the current which pass on to the broadcasting apparatus and are picked up at the receiving station. At the receiving station, the variations in the radio waves produce variations in the light of an electric lamp.

The chief feature which distinguishes the Jenkins method of transmitting pictures from other methods is in the way these changes in the light are distributed on the photographic plate at the receiving end and the way the image of the original is brought piece by piece in front of the light sensitive cell at the sending end.

This is done by an ingenious arrangement of moving glass discs.

At the sending end a set of these discs is placed between the projecting lantern and the box containing the light sensitive cell. The edges of these discs are of varying thickness so that each part of the circumference of the discs acts as a different prism to bend at different degrees the light coming from the lantern. When these overlapping glass discs are placed in motion, the net result is the shifting of the entire projected image, slice by slice, across the light sensitive cell.

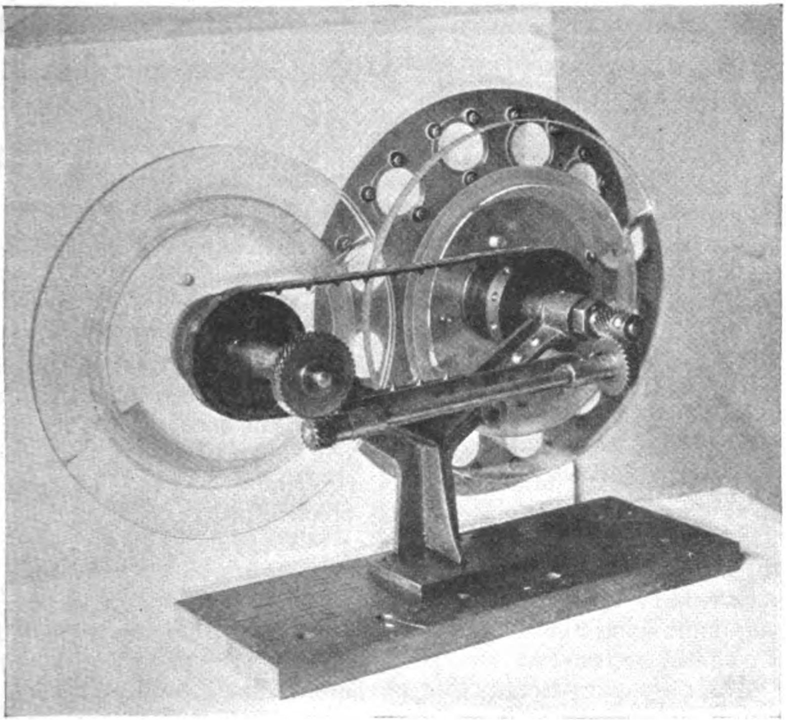
Beautiful half-tone photographs are picked into hundreds of pieces in this way in six minutes and broadcast piece by piece. At the receiving station a similar set of glass discs is placed between the lamp controlled by the incoming waves and the photographic plate. The spinning of this set of discs at exactly the same rate as the set at the sending end distributes the flashes of light on the plate so that an exact reproduction of the original photograph is built up line by line.

One picture in six minutes is, however, a long way from sixteen pictures in one second. To send movies it is necessary to tear down and build up the pictures nearly six thousand times that fast. Obviously, since the speed at which such a picture is sent is determined by the rate at which the image is shifted in front of a single light sensitive cell, the glass discs which shift the image must be tremendously speeded up.

This Mr. Jenkins did. But with the arrangement of discs used for the still pictures, he could not get enough speed. So he devised a new disc, the edges of which are set with a number of tiny lenses, and with it sliced the image up much faster. But even this disc could not carry the image past the light-sensitive cell fast enough to send a complete picture in one-sixteenth part of a second.

Speed, more speed—vastly more speed—was needed. The disc could not be forced to make up the difference without danger of flying to pieces. It was necessary to jazz up other parts of the process.

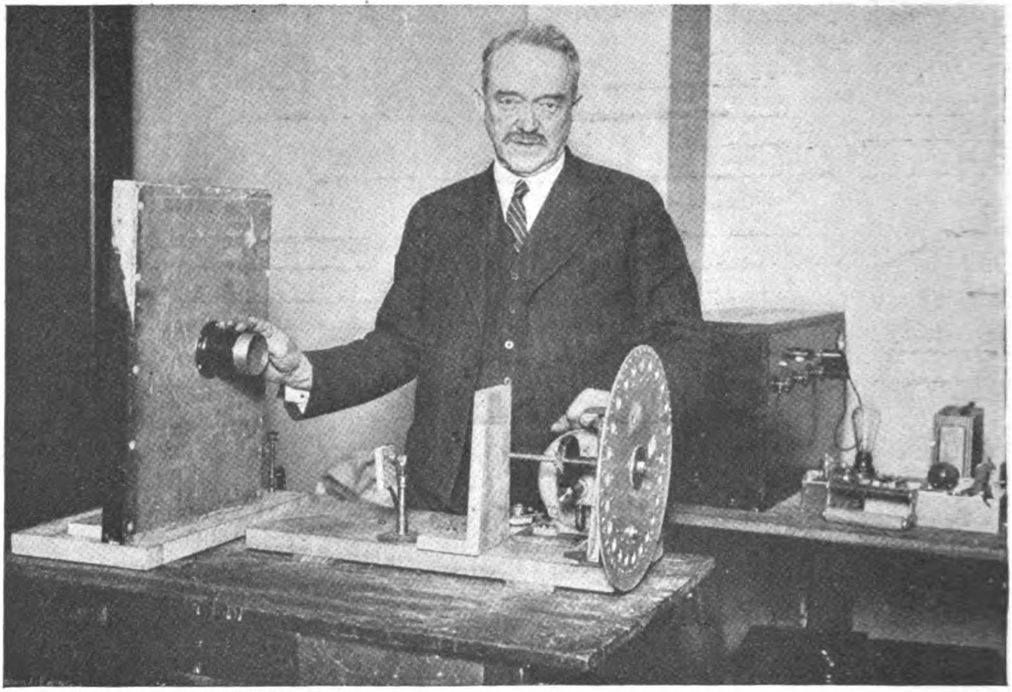
By multiplying the number of light-sensitive cells, Mr. Jenkins found that he could multiply the speed obtained by his disc. Instead of trying to send the entire image slice by slice from top to bottom, past a single light cell, he decided to project it against a box with four holes



From a photograph made for POPULAR RADIO

A DOUBLE DISC MACHINE

This model uses a double disc arrangement instead of a single wheel. The principle of operation is entirely the same as that explained in the caption of the machine shown on page 109. The two discs are used to throw a pencil of light across the screen in shifting lines until a whole picture is built up.



From a photograph made for POPULAR RADIO

THE TRANSMITTER FOR LIVING MOTION PICTURES

The large lens in the mask at the left images the picture of the moving object through the tiny lenses of the rotating wheel onto a large lens similar to that shown in the photograph on page 108. This literally cuts up the image of the moving object in a series of 15 or 16 pictures each second, thus preparing a series of pictures which can be converted to electrical impulses by the light sensitive cell shown in the wooden box on page 110.

in it leading to four separate light-sensitive cells. By this arrangement, while one-quarter of the image is being carried past one light cell, the other three-quarters are also being carried piece by piece past the other three light cells. The image is in this way picked to pieces in four places at once. The resulting current variations are distributed and broadcast as modulations on the one radio carrier wavelength in much the same way that four or more telegraph messages are sent over one wire at the same time.

But even multiplying the speed four times that obtained by the disc alone was not enough. Mr. Jenkins decided to get still greater speed by sending the pictures in larger pieces. Beautiful half-tone photographs must be sent in hundreds of very fine slices or pieces in order to bring out all the fine details. Pictures requiring less detail can be sent in larger pieces. As the silhouette is the simplest form of the human figure, it can be sent in the largest pieces.

The inventor, therefore, devised his "teloramaphone," as he has named it, to show silhouette pictures built up in four sections at once out of forty-eight pieces.

In this way he has achieved the seemingly impossible task of sending sixteen complete pictures a second by radio. So rapidly are these pictures built up as white silhouettes on a black background on the little screen of the teloramaphone that the mechanics of the thing is hardly noticeable. Yet these pictures are built up before your very eyes as you watch the screen. It is not a photographic process like the sending of still pictures has been. The little silhouettes are completely formed by spots of light from four small electric lamps, one for each quarter of the picture, flashing with lightning-like rapidity and shifted on the screen by a revolving disc similar to the one at the sending station and tuned to the same speed with it.

In order to bring the silhouettes out clearly, the greatest contrast between light and dark was needed. Ordinary metal filament incandescent lamps could not be used, because the wires in them stay white hot between rapid pulsations of current. What was needed was a light which would go out the instant the current went off. Finally, after many experiments, Prof. D. M. Moore's glow lamp was adopted. Instead of a wire filament, this little electric lamp has a little well of gas which becomes incandescent when the current goes on, but instantly loses its incandescence when the current stops.

These glow lamps had to be manufactured in the desired size to furnish a spot of light of the proper proportions to build up the silhouette in the required time. In making a detailed photograph, these little lamps with smaller diameter gas wells are used. As other parts of the apparatus are speeded up still further, the smaller lamps can be substituted for those used to make the silhouettes and pictures can be built up in more and smaller pieces. As the smaller pieces are used greater detail will be brought out.

But that is in the future. What is here now is the Jenkins teloramaphone.

The teloramaphone as at present designed looks not unlike the usual large tube-set receiving cabinet. In fact, it is that and something more; for it contains a panel in which is a dark screen behind which flash the spots of light which are built up into the white silhouette upon a dark background.

On the same antennas which now catch the audible broadcast, we may soon receive the spoken and acted play as well as played and acted music. When the music is not to our ear, we can shut off the sounds and in the quiet of our home watch "the magic shadow shapes that come and go."

There on the little screen before us, we may find relief from the complexities of modern life in dainty, simple little white-shadow plays presented with a directness and vigor practically unknown in our more detailed photo and spoken drama today.

At least that is what we can expect if we can judge by the past. In Europe the silhouette drama was once a leading form of entertainment. In the twelfth and thirteenth centuries, the "shadow theater" produced actors which became renowned. Even down to 1850, the silhouette maintained a certain vogue; but in the latter part of the preceding century, the shadow theater probably reached its greatest popularity. Special plays were written for performance on its stage. In Paris, especially, it became the rage in high society.

Yet in all the shadow shows from King Tut's time on, the spectators had to go to the show. By the teloramaphone revival of the old art of pantomime, the show will come to the spectator. Radio waves will bring into homes throughout the country plays and dances. Bedtime stories will not only be illustrated, but told entirely in silhouette action without interfering with father reading the newspaper.

Some people, no doubt, will prefer the trip to the corner theater in order to see more detailed motion pictures. Yet there is also promise in this apparatus for them. The silhouette movie may reasonably be expected to repeat the history of those silhouette paper cut-outs and paintings on glass so popular in great-grandfather's day. As they were the pioneers for the cheap photograph, so the four-cell teloramaphone may be the pioneer not only of detailed movies but of radio vision.

For the motion picture film used at the broadcasting station is even now merely a convenience. Shadows of the moving hands or other things inserted between the light and the photo-electric cell are transmitted just as easily as the silhouette on the film. To get away from mere shadows, the teloramic process only has to be speeded up sufficiently.

The MEN WHO

8th Installment

The Creator of a Modulation System

E. H. Colpitts *has been identified with radio research and practice for a number of years, during which time he developed a modulation system. His most outstanding contribution to radio science has been the invention of the Colpitts oscillator which has been of great importance in the development of radiotelephony.*

DeForest Radio Co.

The Inventor of a Tikker

With *the advent of the arc transmission system it became necessary to devise a means of breaking up the continuous-wave train transmitted from a sending station so that it could be made audible at the receiving end.* Charles L. Logwood *invented a device known as the "tikker" which was similar to that invented by Dr. Austin. He also developed some important oscillating circuits.*

The Designer of a Transmitting Arc

E. L. Chaffee *is identified with radio science through his researches in electric oscillations* In Vacuo *and in regeneration. His most outstanding contribution was the Chaffee arc and his gap that was used in conjunction with the arc in radiotelephone work.*

MADE RADIO

The Inventor of a Neutrodyne System

THE *neutrodyne system of radio-frequency amplification, so-called because it prevents feedback through the amplifier and thus eliminates radiation, was invented in 1922 by* PROFESSOR L. A. HAZELTINE. *This neutrodyne system was first worked out "on paper" by mathematics and was then applied to the construction of a receiver.*

Bachrach

* * *

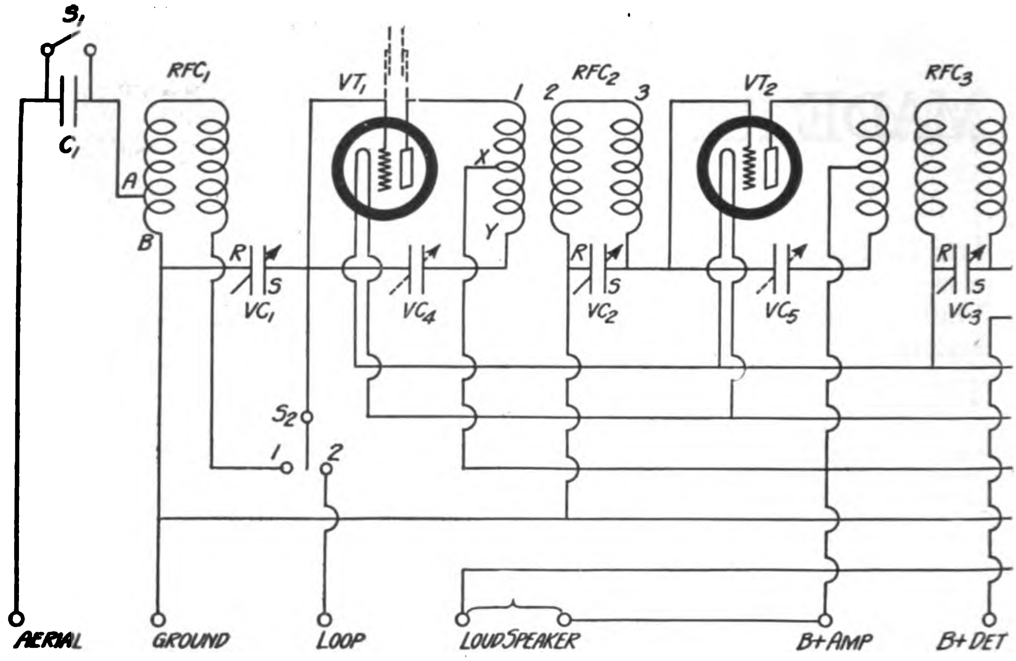
He Invented a Regenerative Circuit

A REGENERATIVE *circuit which is notable for its flexibility was invented by* A. MEISSNER *of Germany. This circuit embraces a feedback system and magnetic coupling between the load circuit and the plate circuit of the tube. The feedback system in the Meissner circuit does not depend upon the voltage drop across a reactance in the load circuit as it does in some of the other systems. It has proved particularly applicable for radio installations on aircraft.*

* * *

The First Man to Signal by an Electrostatic System

A. FREDERICK COLLINS, *an English inventor, after experimenting with systems of wireless signalling, developed in 1900 an electrostatic system which carried speech a distance of about eight miles. He is credited in some British circles with being one of the inventors of the radiotelephone.*



HOW TO GET THE MOST OUT OF

YOUR READY-MADE RECEIVER

No. 7: The Grebe Synchrophase Receiver

This series of articles explains the theory, operation, equipment and care of standard receiving sets

This series does not indorse the product of any manufacturer or make comparisons between receivers. The sets already described include: No. 1, the Eagle Neutrodyne; No. 2, the Radiola Superheterodyne; No. 3, the Melco Supreme Receiver; No. 4, the Crosley Trirdyn; No. 5, the De Forest Reflex; No. 6, the Atwater Kent.

By S. GORDON TAYLOR

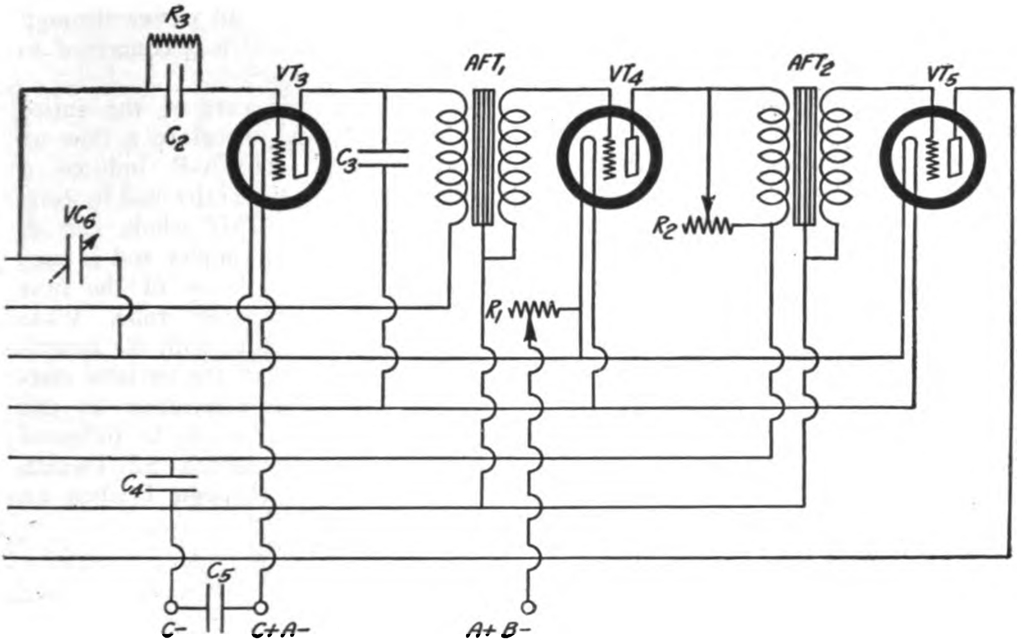
THE Grebe Synchrophase receiver is of the tuned-radio-frequency type and makes use of the neutralization method for preventing oscillation in the radio-frequency amplifier portion.

An oscillating condition of the vacuum tubes in a radio-frequency amplifier usually prevents—or at least distorts—reception.

The feed-back in the circuits of a tube results from magnetic coupling between coils in the output and input circuits of the tube and also from the coupling effect of the capacity between the tube electrodes. The former type of coupling is known as "inductive coupling," while the latter is called "capacitative coupling."

In the Grebe receiver the effect of inductive coupling is practically eliminated by the use of a special type of coils, known as "binocular" coils.

This name was derived from the shape of the coil, a picture of which is shown in Figure 3. With this arrangement any inductive coupling from an-



WIRING DIAGRAM OF THE GREBE SYNCHROPHASE RECEIVER

Figure 1: *The designating letters refer to parts described in the text and also shown in the other figures.*

other part of the circuit will affect both halves of the coil but in opposite directions; therefore, the induced energy in one half will oppose the induced energy in the other half. And inasmuch as the induced energy is equal in the two halves, the resulting energy flow for the entire coil is zero. Thus the undesirable inductive coupling is eliminated.

In the wiring diagram, Figure 1, coils 2 and 3 of the coupler RFC represent the two halves of the binocular coil. Coil No. 1 of this coupler is the primary coil and is connected in the plate or output circuit of the first tube while coils 2 and 3 are in the grid or input circuit of the second tube. Coil No. 1 cannot be seen in Figure 3 as it is placed inside of coil 2.

The capacitative coupling is eliminated in this receiver by means of the neutralization method. As was explained before, a condenser inserted across the plate and grid circuits of a vacuum tube results in a tendency for some of the energy to flow from the plate circuit back to the grid circuit, in which case the tube becomes a miniature generator of radio-frequency currents; in other words, it reaches a condition of oscillation, thus interfering with its functioning as an amplifier.

In the radio-frequency amplifier a condenser is not actually inserted between these two circuits, but unfortunately the opposing surfaces of the grid and plate of the vacuum tube act as such a tiny condenser. Inasmuch as these two elements are indispensable to a vacuum tube used as an amplifier, some means must be found of combating the tendency to oscillate. To do this another circuit is added and so arranged that its current-flow tendency is opposed to that from plate to grid.

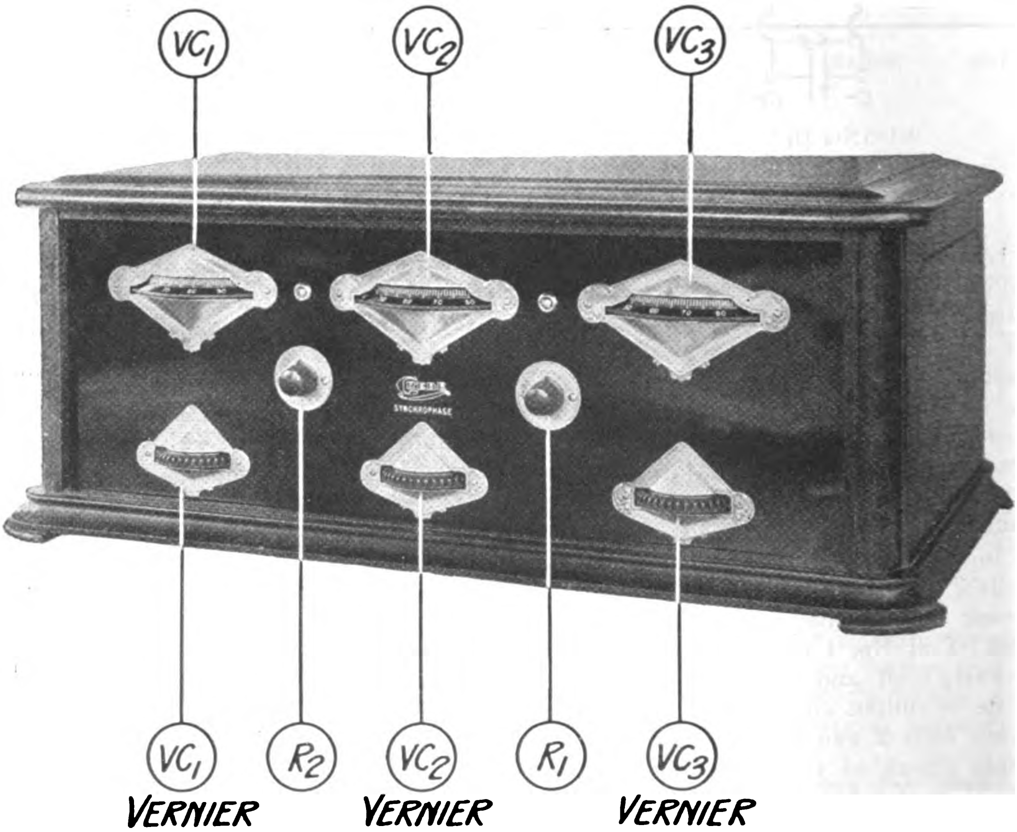
In Figure 1, the capacity which causes the trouble is shown by dotted lines at VT1. The neutralizing circuit consists of the coil X-Y and the condenser VC4.

How the Receiver Works

The signals from a broadcasting station are intercepted by the antenna and are brought to the receiver through terminal No. 1. From here they pass on through condenser C1, or switch S1 if the latter is closed. This condenser is provided to adapt the receiver to oversized aerials. By allowing the incoming signals to pass through this condenser the same effect is obtained as would result from using a smaller antenna. With a normal antenna the switch S1 is closed, thus short circuiting C1 and allowing the signal to pass on without going through the condenser.

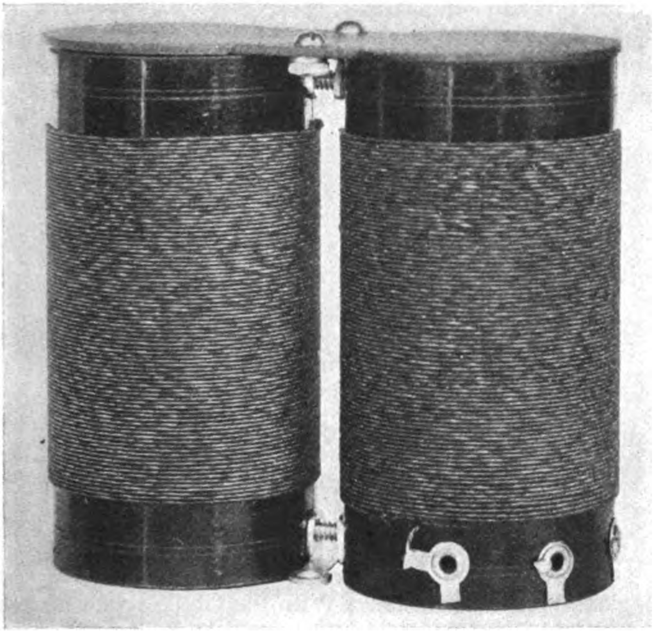
The signal energy then flows into the coil of RFC1 at A and passes through a few turns to B which is connected to the ground.

The coil A-B is part of the entire coil of RFC1, and therefore a flow of energy through coil A-B induces a similar current in the entire coil by conductive coupling. This whole coil is the secondary of the coupler and is connected in the grid circuit of the first radio-frequency amplifier tube, VT1. It is tuned to resonance with the incoming signal by means of the variable condenser VC1. The connection to the grid of the tube may easily be followed down through the switch S2 (which must be connected to point 1 when an



THE PANEL VIEW OF THE RECEIVER

FIGURE 2: *Tuning is accomplished with the three upper controls, and the three lower controls which permit extremely small variations for sharp tuning. The left-hand knob controls the volume and is usually set on point 4 or 5 unless extreme volume is desired, when it is set on 6. The other knob controls the filament current and is usually set at 4.*



THE GREBE BINOCULAR COIL

FIGURE 3: *By winding the coil in two connected parts its magnetic field is limited and is little affected by stray currents from other parts of the circuit.*

outdoor antenna is used) and from there to the grid.

When a loop antenna is used it is connected to the terminals marked "Ground" and "Loop." In such a case, the coil RFC1 is not used. The loop acts not only as an antenna but also as a coupler coil. By connecting the loop as explained, and throwing S2 to point 2, the signals picked up by the loop are impressed on the grid of the tube as before, and the loop is tuned by means of the condenser VC1.

The signals impressed on the grid of VT1 result in amplified signal energy flowing in the plate circuit of this tube. The additional energy required for the amplified signal is obtained from the high-voltage "B" battery which connects to the plate of the tube through point X of the primary of coupler RFC2.

By the process of electromagnetic induction the energy flowing through this primary sets up a similar flow of energy through the secondary coil which consists of coils 2 and 3. This secondary coil is also tuned to resonance with the incoming signal by means of condenser VC2 and the signal is impressed on the grid of the second radio-frequency amplifier tube VT2. Here it is further amplified in the same manner as before and passed on to VT3 through the coupler RFC3.

Up to this point the signal has been twice amplified but is still in the form of an alternating current of too high a frequency to be audible to the human ear. The next step, therefore, is to change its form to make it audible, and this is the function performed by VT3 which is called the detector tube. The condenser C2 and the grid-leak R3 are provided to aid in this rectifying action.

The purpose of radio-frequency amplification is to increase the sensitivity of the receiver; therefore, if headphones could be connected in the output circuit of VT3 signals would be audible, even from distant broadcasting stations.

Having provided ample sensitivity,

the next requirement is to increase volume to make possible the use of a loudspeaker. It is for this purpose that the audio-frequency amplifier, consisting of VT4 and VT5 is used. The coupler coils used are different from those used with the first and second tubes but their function and circuits are much the same. The energy in the detector plate circuit passes through the primary of the coupler (audio-frequency transformer) AFT1 and induces a current flow in the secondary which is impressed on the grid of VT4. The signal is then amplified through the action of vacuum tube VT4, is passed on to VT5 in the same way and is there again amplified. From VT5 it passes to the loudspeaker.

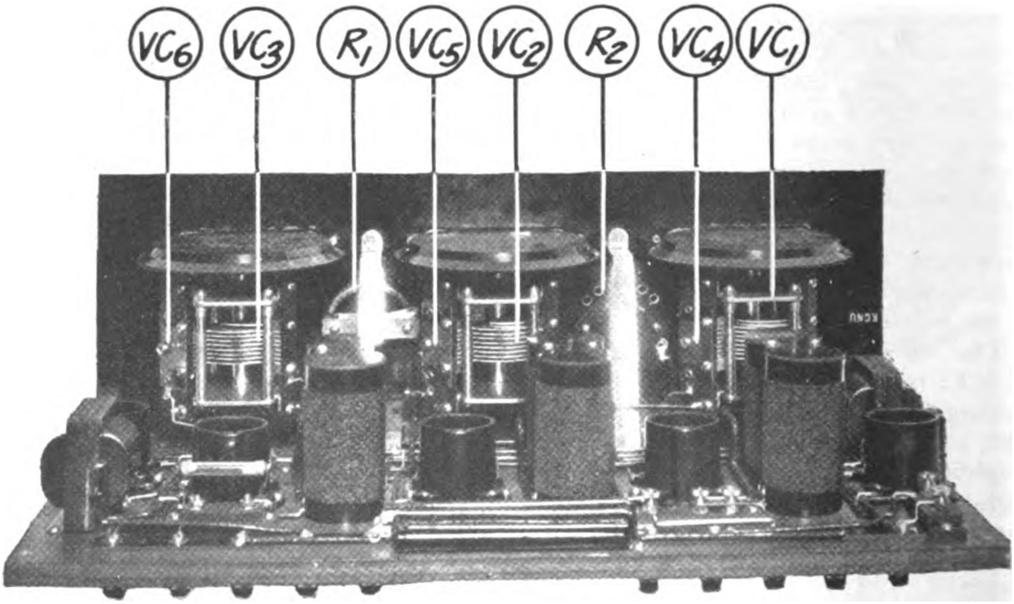
In the case of signals received from nearby broadcasting stations the volume in the loudspeaker would be too great for comfort in an ordinary room so the variable resistance R2 is provided to permit reduction of volume to a desired degree.

Construction of the Receiver

The general construction of the receiver is clearly shown in the accompanying illustrations. The set is intended for use with external "A," "B" and "C" batteries and with either an outdoor, an indoor or a loop antenna.

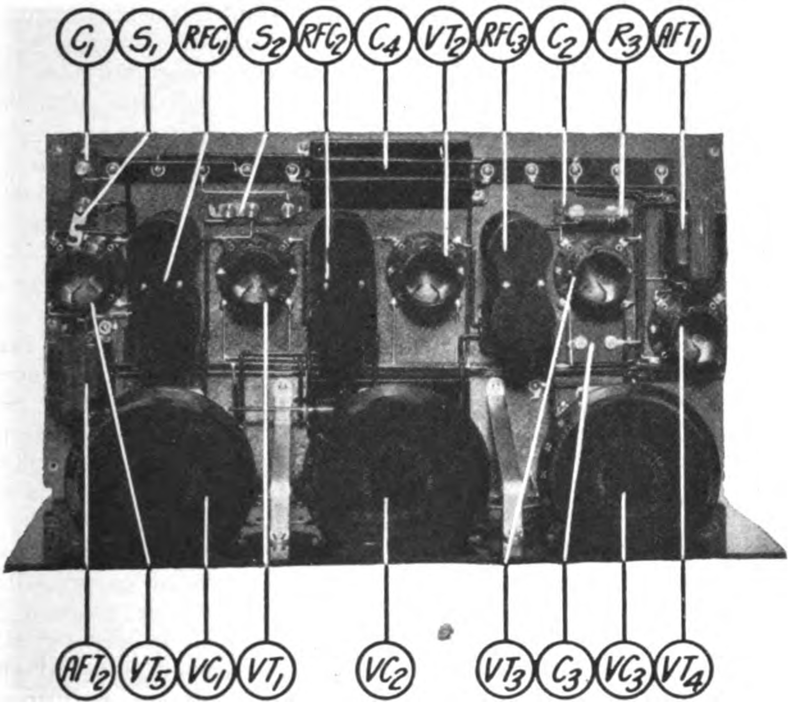
All of the parts are made by the Grebe Company, and are especially designed for this receiver.

One feature of the three large variable condensers used for tuning lies in the fact that they are of the so-called "straightline-frequency type." With the ordinary type of condenser the low-wave broadcasting stations come so close together on the lower part of the condenser dials that it is sometimes difficult to separate them and the tuning of such stations is extremely critical. With the Grebe type of condensers, however, this difficulty is partially avoided. The spacing on the dials between low-wave stations is greatly increased while spacing between the higher-wave stations (where great spacing is not needed) is



THE REAR VIEW OF THE "WORKS"

FIGURE 4: *The instrument layout is here clearly shown. The designating letters are the same as those shown in Figure 1. The balancing condensers VC4 and VC5 are in plain view here; the use of them is explained in the text.*



ANOTHER INSIDE VIEW

FIGURE 5: *The instruments which are not mounted on the panel are all on a sub-base, so that the whole set may be removed from the cabinet for inspection or repair. Experimenters are not advised to attempt such removal unless it is absolutely necessary, however; even then it is better for the novice to leave such work to the dealer or the manufacturer.*

decreased. In effect this spreads the entire broadcast waveband evenly over the whole scale on the dials, thus simplifying the tuning process.

The design of the neutralizing condensers VC4 and VC5 also facilitates obtaining maximum results from the receiver. Neutralizing condensers are usually adjusted and sealed before a manufactured receiver leaves the factory. Difficulty is sometimes encountered where this is the case because tubes, other than those used when the receiver was adjusted, may have different internal capacities, thus making the neutralizing circuit only partially effective. In the case of the Grebe receiver the owner of the receiver can readjust his own neutralizing capacities to take care of any variations in his own tubes. Instructions for this neutralizing adjustment will be given later.

A condenser, VC6, is provided to permit synchronizing the dial settings of the condensers VC2 and VC3. By once adjusting VC6 these two variable condensers can be made to tune just alike for a given wavelength, therefore a given broadcasting station may be tuned in with both of these condensers set at exactly the same reading.

The type and layout of controls on the panel are such as to permit operation of the three tuning controls at the same time. The controls for condenser VC2 and VC3 can be moved simultaneously with the thumb and first finger of the right hand, while the control of VC1 is being moved with the left hand. This eliminates some of the difficulty in tuning encountered in many receivers which have three controls.

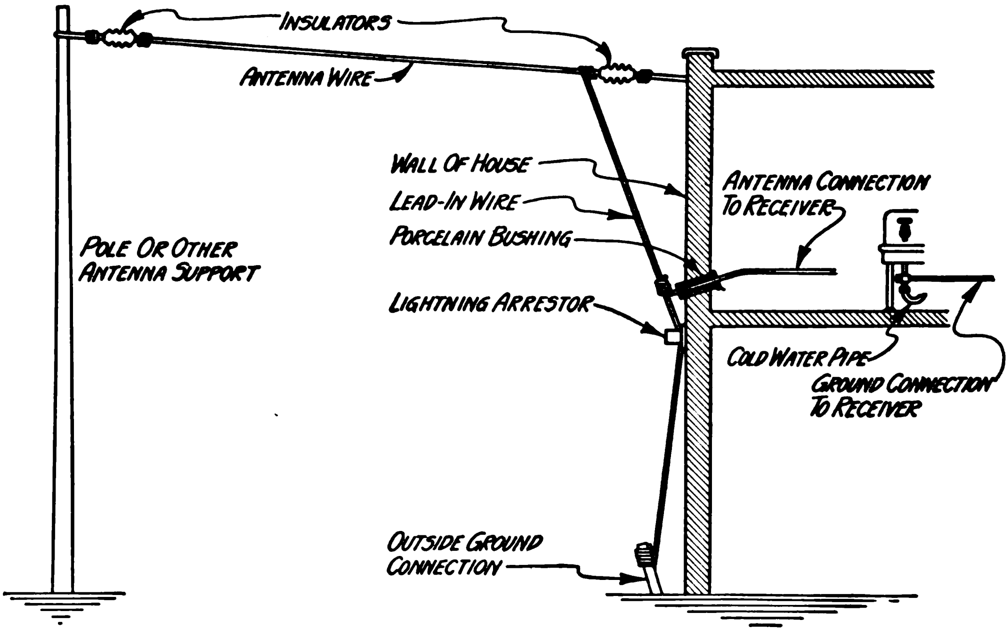
The Antenna and Ground

Almost any antenna is suitable for use with the Synchrophase receiver. A wire strung around the picture moulding will give good results, especially if it runs through three or four rooms in nearly a straight line, rather than around the four sides of one or more rooms. Better results will, of course, be obtained with an outdoor antenna, which may be anywhere from 50 to 200 feet in length. Probably the best all around arrangement is a single wire about 100 feet in length including the lead-in. The layout of such an antenna is shown in Figure 6. A longer antenna will produce greater volume and distance but will have a tendency to broaden tuning thus resulting in interference between stations operating on nearly the same wavelength. In any event the condenser C1 and switch S1 help to take care of this, as explained above.

A short antenna will not produce quite as much volume on distant stations nor will it permit reception from such great distances as will the 100 foot wire. However, a short outdoor antenna (or an indoor antenna) picks up less static and this is naturally an important consideration for even local reception durin the summer.

The ground connection may be made to a cold water pipe or any other pipe system, which connects with the ground —with the exception of gas pipes. Hot water pipes or steam radiators usually provide suitable ground connections but gas pipes are usually insulated from the ground by rubber washers in the pipeline near the meter.

If no pipelines are available in the house a quantity of copper wire buried in moist ground or dropped into the water of a well or cistern will serve. In any case a good electrical connection should be made to the ground line


INSULATORS
ANTENNA WIRE
WALL OF HOUSE
LEAD-IN WIRE
PORCELAIN BUSHING
LIGHTNING ARRESTOR
POLE OR OTHER ANTENNA SUPPORT
ANTENNA CONNECTION TO RECEIVER
COLD WATER PIPE
GROUND CONNECTION TO RECEIVER
OUTSIDE GROUND CONNECTION

A SUGGESTION FOR THE ANTENNA LAYOUT

FIGURE 6: *The design of the average antenna is necessarily governed by physical conditions such as yard space-limitations. Regardless of conditions many of the ideas incorporated in antenna illustrated in this figure may be used to advantage. The antenna for use with the Grebe receiver should preferably be about 100 feet in length, measured between insulators, although good results are obtainable with shorter spans.*

From a photograph made for POPULAR RADIO

TWO HANDED OPERATION OF THE THREE TUNING CONTROLS

Here the author demonstrates the method of tuning the three dials simultaneously, thus eliminating the necessity for a third hand.

selected. If it be a pipe any paint or other coating on the pipe should be filed off until the pipe is bright and shiny at the point where connection is to be made and connection made by means of a regular ground clamp.

If for any reason the use of an antenna is not practical, a small loop antenna may be used. This is connected to terminals 2 and 3 (Figure 7).

A lightning arrester may be connected as shown in Figure 6.

What Vacuum Tubes to Use

This receiver is designed to use vacuum tubes of the UV-201-a type throughout. These may be the UV-201-a, the C-301-a—or the De Forest DV-2, These are all "hard" tubes which require the use of a storage "A" battery for filament-current supply, and consume approximately ¼ ampere each. The use of a "soft" detector tube, such as the UV-200, is not recommended. A special model of this receiver is on the market for use with dry-cell tubes—one which is especially designed for operation with these tubes. Satisfactory results will not be obtained if dry-cell tubes are used with the model described in this article.

What Batteries to Use

This receiver uses three separate types of batteries—the "A," "B" and "C" batteries.

The "A" battery must be of the storage type. This storage battery may have a rated ampere-hour capacity of between 75 to 150. A battery charger is also desirable so that the battery may be charged at home, thus avoiding the inconvenience of carting the battery to a neighboring charging station; or the expense of having the battery called for and delivered by the charging station.

Connections for a battery charger are shown in Figure 7, for use where the house is equipped with alternating current for lighting.

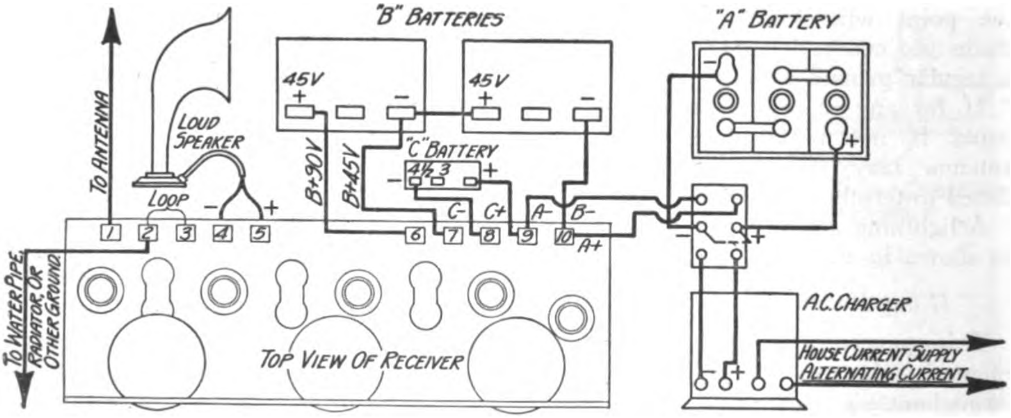
In the case of a direct-current house supply it is important that the polarity of the current first be determined. This may be done by holding the two ends of the leads (from a light socket) a half-inch apart and dipping them into a cup of water to which a half teaspoonful of salt has been added. Bubbles will rise from one of the wires when the current is turned on, and this wire is the negative (—) side of the line. In making this test there is no danger provided insulated wire is used and the hands are not allowed to come in contact with the bare ends of the wires. Connections for a bank of lamps (to be used for the charging resistance with direct-current supply) are shown in Figure 8. No other apparatus is needed for charging from direct-current mains.

It is essential that a hydrometer be obtained also, to determine when it is in need of recharging. When the hydrometer shows a reading of 1,185 it is an indication that the battery needs charging. A reading of approximately 1,285 indicates a fully-charged battery. Actually a fully discharged battery will give a reading of about 1,150 but it should never be allowed to run down to this point as the battery is quite likely to be injured.

The "B" battery consists of four 22½ volt batteries, or two 45-volt units. In either case the total voltage required is 90. Large size batteries (either 22½ or 45-volt units) are desirable because their life is approximately 16 times that of the small size of the same voltage; and the initial cost is only about twice the cost of the others. The new extra large "Heavy Duty" batteries are recommended, however, as they offer still greater economy. This is made clear in the table on page 126.

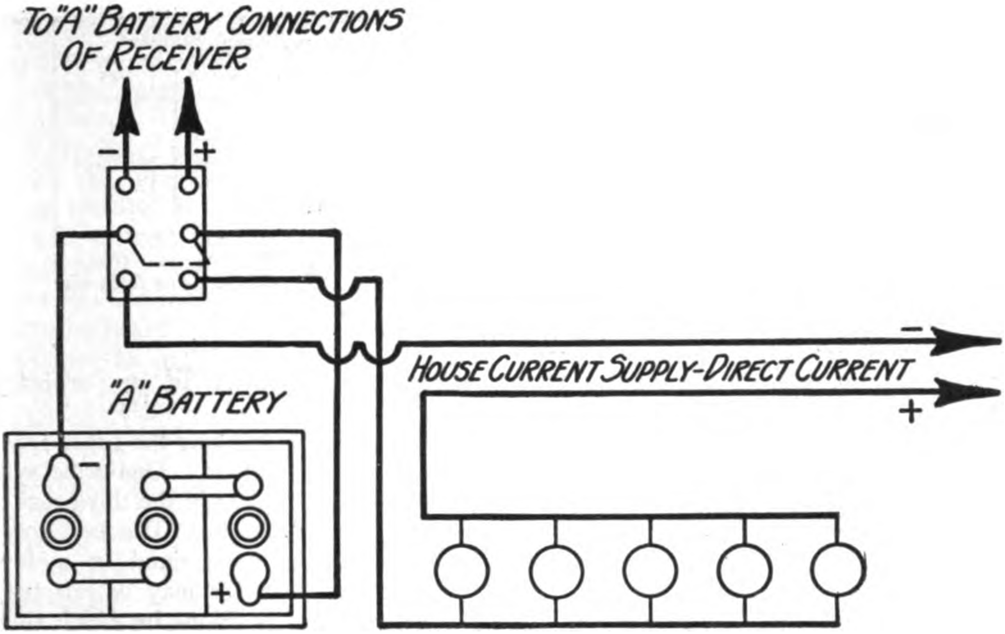
Storage "B" batteries may also be used. In fact the use of them will reduce the battery upkeep cost in the long run and the service obtained from them, provided they are given an occasional charge, will be as satisfactory as that obtained from batteries of the dry-cell type.

Charging equipment for such batteries may be purchased for a small sum



CONNECTIONS FOR THE COMPLETE EQUIPMENT

FIGURE 7: *In addition to the connections for the batteries, loudspeaker, antenna and ground, connections for the battery charger are shown. A switch is incorporated in the "A" battery circuit. When thrown to the up position the battery is connected to the receiver and when thrown down connects to the charger; there is then no danger of starting the charger while the battery is still connected to the receiver.*


To "A" Battery Connections Of Receiver
–
+
"A" Battery
–
+
House Current Supply-Direct Current
–
+

CHARGING THE "A" BATTERY FROM DIRECT CURRENT HOUSE SUPPLY

FIGURE 8: *In this case no charger is needed. Only resistance is required and this is furnished by the use of five ordinary 100 watt lamps connected as shown. If desired a special charging resistance may be purchased to use in place of the lamps.*

and where the house supply is alternating current an attachment may be purchased to permit the regular "A" battery charger to be used for charging the storage "B" batteries also.

The "C" battery is of the dry-cell type and consists of a regular 4½ volt unit sold for this use. There is practically no current consumed from this battery and its life is therefore long. It will be good until it just naturally dies of old age. It will very likely last a year.

The Operation of the Receiver

The connections for the batteries, antenna, ground and loudspeaker are shown in Figure 7. These connections are all self-explanatory, with the possible exception of the connections to the terminals marked 1, 2 and 3 in Figure 7. When an outdoor or indoor antenna is used, it is connected to terminal No. 1. When a loop antenna is used, however, its two ends are connected to terminals 2 and 3 and terminal No. 1 is left unconnected. In either case the ground is connected to terminal No. 2. When an outdoor or indoor antenna is used the switch S2 is swung around so as to make contact with point No. 1 (the left-hand point looking down on the receiver from the top). When a loop antenna is used this switch arm is connected to point No. 2.

After the receiver has been connected up in accordance with the above, turn the "volume increase" knob to point 6 and the "filament increase" knob to zero. Next insert the five vacuum tubes in their sockets and turn the "filament increase" knob to 4. This will light the tubes and the receiver is then ready for operation.

To tune in a station the dial settings shown in the tuning chart below will be approximately correct for all receivers of this type and model. The best plan is to select a powerful nearby station which is known to be in operation at the

Average hours use per day	*"Large" size batteries*			*"Heavy Duty" batteries*		
	2	3	4	2	3	4
(*"C" battery voltage*)						
4½ volts	222 days	144 days	105 days	388 days	259 days	194 days
3 "	154 "	93 "	63 "	275 "	173 "	121 "
1½ "	120 "	70 "	47 "	220 "	131 "	91 "

This table shows the effect of the "C" battery on the life of the "B" batteries. Greatest economy in operation is obtained when using 4½ volts of "C" battery. The table also shows the much longer life of the "Heavy Duty" type "B" batteries.

time. Then consult the chart to ascertain the dial settings for that station. If that particular station is not shown on the chart, set the dials for the station shown, with a wavelength nearest to that of the station which you desire to tune in. If the receiver is in operation in Los Angeles, for instance, and KHJ of that city operating on 404 meters is the station which you wish to tune in, set the dials as shown on the chart for station WOR which operates on 405 meters. These dial settings will be nearly correct for KHJ; only a slight variation will bring in the desired station.

After one station has been tuned in in this manner, it will be a simple matter to tune in others. The three dials should be moved in unison, manipulating the left-hand dial with the left hand, the other two with the thumb and forefinger of the right hand. This movement should be slow, as it is an easy matter to slip over stations, especially if they be distantly located. When another station is heard readjust each of the three dials slightly to bring it in with maximum volume.

After this tuning process has been practiced a short time it will be well to investigate some of the refinements of tuning. First of all, try different settings of the "volume increase" knob while a station is tuned in. Points 3, 4 or 5 usually provide plenty of volume on all but distant stations. In a large hall, or in receiving distant stations point 6 is useful, otherwise it will give too much volume for comfort in an ordinary room.

Next try interchanging the tubes from one socket to another. One tube will sometimes work better in the third socket than in the fourth, etc. The best combination can be determined in a few minutes and the tubes may be left permanently in the positions in which they give the best results.

These receivers are carefully balanced before they leave the factory, but when the purchaser of the receiver puts it into operation he may find that it oscillates or whistles when he tries to tune in stations in the lower or higher wavelengths.

Where this condition is found it will be necessary for the owner to rebalance the receiver himself, or take it to his dealer to have it done. It is not a difficult task, however, and it is to facilitate this process that the adjusting screws on condensers VC4 and VC5 are provided.

If it is found that the receiver oscillates only when high-wave stations are tuned in the screw on VC4 should be turned slightly in the clockwise direction, keeping the signal tuned in in the meantime. A small screw-driver with a wood handle is recommended for this purpose. This screw should be adjusted in this direction a little at a time until the oscillation ceases.

If oscillation takes place only on the low-wave stations, an adjustment should be made on condenser VC5, in the same manner described for VC4.

In some cases it may even be found

that the receiver oscillates to a certain extent on all wavelengths. In such a case the balancing process is somewhat different. The receiver should be left all connected in readiness for reception, with the tubes turned on. The second and third dials from the left are then set at 40, and the left-hand dial at 100. Dial No. 2 is then rotated between 30 and 50. At some point a click will probably be heard. If not, turn the screw of VC5 in an anticlockwise direction until a click is heard as dial No. 2 is rotated back and forth from 30 to 50. Then turn the screw in a clockwise direction until the click disappears, and approximately a quarter turn beyond this point. This finishes the balancing of VC5.

Next set all dials at 40 and adjust balancing condenser VC4 in the same manner just described, but this time rotating the left-hand dial back and forth between 30 and 50.

There may still be slight signs of oscillation on the high waves, or possibly the low waves. If so a small adjustment of the balancing condensers as described first will remedy the trouble.

Finally it is well to know that the "C" battery voltage used has a strong influence over the life of the "B" batteries and therefore over the upkeep cost of the receiver. The tabulation above demonstrates that the life of the "B" batteries is much greater when the "C" battery voltage is 4½ than when it is 1½ or 3. On the other hand, it is sometimes found that the tone quality and reproduction of the receiver improve somewhat with a decrease of "C" battery voltage from 4½ to 3. This evidently is not always the case, but where it is found to be so, it is up to the operator to decide whether tone quality or maximum economy is the more important consideration.

Charting the Receiver

Tuning will be simple if a record sheet is kept, on which are recorded the dial settings for each station as it is tuned in for the first time.

A record of a few stations is shown below, in the form of a convenient chart. The antenna used when this chart was made up was a short one and there was no occasion to make use of the condenser C1. If a long antenna is used it will be necessary at times to connect C1 into the circuit no doubt. For that reason it will be well to add another column to the chart to note whether or not S1 is open or closed when the dial settings for each station are recorded. This is done because the setting of the dial of VC1 varies slightly according to whether S1 is open or closed.

Wave-length	*Station*	VC_1	VC_2	VC_3
526	WNYC	90	91	90
509	WIP	87	88	87
492	WEAF	83	83	83
475	WEEI	80	80	80
468	WCAP	78	78	78
455	WJZ	74	74	74
405	WOR	64	64	63
394	WLIT	62	62	62
379	WGY	59	59	59
360	WHN	54	54	54
344	WCBD	49	49	49
333	WBZ	46	46	46
315	WGBS	41	41	41
300	WPG	36	36	36

"In the Experimenter's Laboratory"

BEGINNING *in the next issue—for September—*POPULAR RADIO *will publish a new and essentially helpful department that will be conducted by the Technical Staff of the* POPULAR RADIO LABORATORY *for the particular benefit of the radio amateur and for the broadcast listener who is interested in experimental work and who seeks to attain better results from his radio equipment—and who may thus profit from the constant experimental work of a skilled and experienced staff of experts.*

General Electric

THE INVENTORS AND THEIR NEW UNIT

The working mechanism of the vibrating cone loudspeaker is here shown in the hands of its co-designers. In the background is shown another instrument fully set up in a cabinet.

A New Type of Hornless Loudspeaker

By W. T. MEENAM

THE ordinary loudspeaker usually approaches true reproduction only within a limited frequency range. Low notes are usually shattered; they are lost almost entirely or else they are produced only as overtones.

Here is a new device, developed by Chester W. Rice and Edward W. Kellogg, which utilizes a vibrating cone to set up the air waves and gives faithful reproduction from the deepest organ notes to the highest violin harmonics.

Sound is, of course, produced by vibrations which are sent through the air as pulsations. The more vibrations a second, the higher is the pitch of the sound. In the usual telephone receiver the sound is produced by vibrations of a metal diaphragm which is affected by the varying strength of an electromagnet behind it. This type of reproducer is satisfactory for headphones, as the air gap between the diaphragm and the eardrum through which distance the sound vibrations must travel is small, and diaphragm vibrations of small amplitude are sufficient. For loudspeaker operation, however, the telephone unit must be more powerful and is usually coupled with a horn. It will be found that such an arrangement does not always reproduce both high and low notes with the same precision, and it is usually the low notes which are slighted.

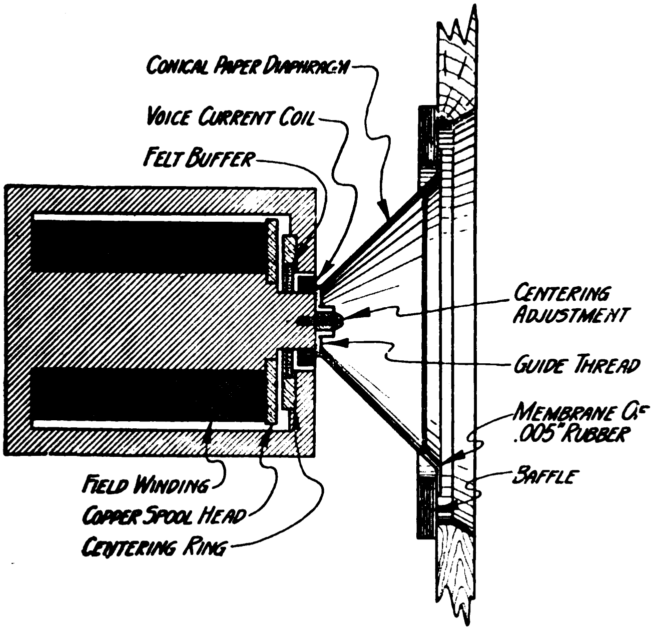
To radiate low notes more effectively there must be more air moved with each swing of the diaphragm. The loudspeaker may be thought of as an air pump. If an air pump which will give a large movement of air with each stroke is desired, a large piston area and a long stroke should be used. The telephone receiver type of speaker is not suited to the purpose of obtaining a long stroke, first, because the movable iron will strike the poles of the magnet if it swings far, and second, because it is in an unstable position and with the very flexible diaphragm support which is essential for the long stroke, there is not enough stiffness to hold the iron away from the magnet poles.

In the new hornless loudspeaker, the familiar moving-coil type of drive is employed. If a copper wire is placed between the poles of a magnet, the wire will be pushed sidewise when a current is sent through the wire.

The wire is wound into a coil, and as it moves parallel to the faces of the magnet poles instead of toward and away from them, there is no limit to the distance it can move. The varying currents from the radio set are passed through an amplifier to the moving coil. The strength of the magnetic force on the coil of copper wire varies with this current, and the coil is thus caused to vibrate. In this device the moving coil is attached to a diaphragm, consisting of a paper cone about six inches in diameter, the outer edge of which is supported by a membrane of thin rubber.

An important feature of this new hornless loudspeaker is the baffle board which surrounds the diaphragm and which serves as the front of the cabinet. The baffle does not itself radiate sound, but it prevents air from circulating between the front and back of the diaphragm.

The cabinet contains, in addition to the speaker itself, a rectifier and amplifier, power for the operation of which is taken from the alternating-current lighting circuit. The amplification obtained from this new device is sufficient to produce, in the case of local stations, clear loudspeaker signals from a crystal receiver, provided that the latter gives clear headphone reception.



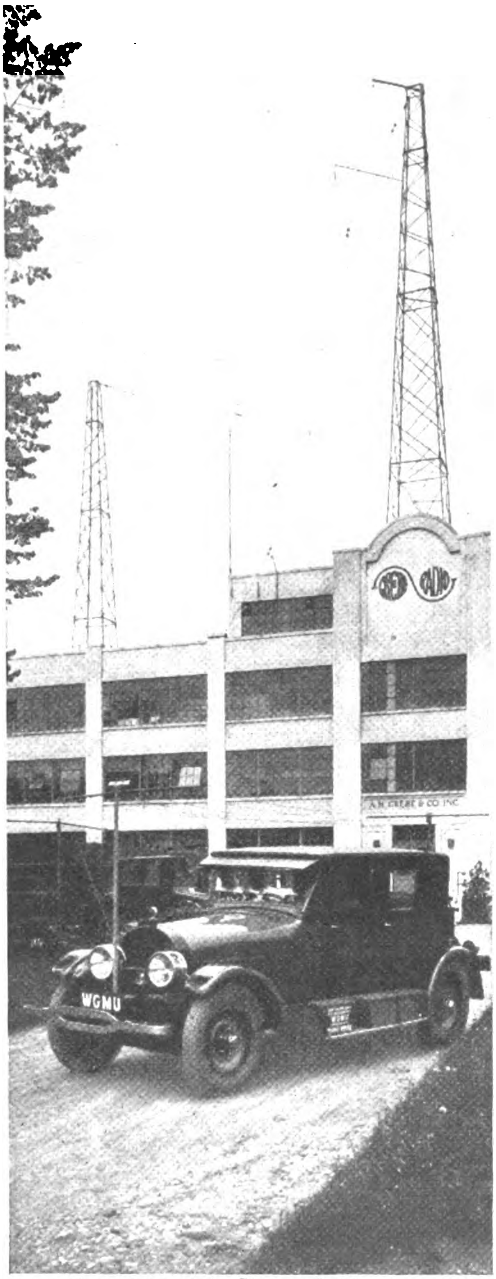
THE WORKING PRINCIPLE OF THE UNIT

This diagram shows the various parts included in the design and the general mechanical arrangement. Notice that the voice-current coil which furnishes movement to the conical, paper diaphragm moves back and forth in a horizontal position at right angles to the magnet.

A MOBILE

The advent of the practical, motorized short-wave relay station into the realm of broadcasting marks the beginning of a new era. With its aid, a description of any outdoor event, no matter where located, may be transmitted through a regular broadcasting station.

By DAVID LAY



From a photograph made for POPULAR RADIO

THE NEW TYPE OF "RADIO REPORTER"

FIGURE 1: *The short-wave transmitter on a motor car leaving the main broadcasting station for a trip to the locality of a distant event; the descripition of the event will be relayed back to the main station and put on the air through the large antenna.*

HERETOFORE ordinary broadcasting has been confined to events which have taken place directly in the broadcasting studio or events that have been picked up by means of a specially installed telephone line direct to the location where the event is taking place.

It is true that in a few instances (such as the broadcasting of the recent total eclipse and the broadcasting of the race between the motorboat *Baby Gar IV* and the Twentieth Century Limited) that the original signals were picked up from a mobile station located in an airplane.

The chief problem in this latter method of broadcasting was to devise a connecting link between the event being described and the large high power broadcasting station operating on a regular wavelength.

The best solution to this problem lies in the use of portable short-wave pick-up stations working in conjunction with the regular broadcasting stations.

Such a mobile station, the call letters of which are WGMU, has already been placed in operation by A. H. Grebe and Company. It is an ideal short-wave relay installation, operating on 63 meters in conjunction with station WAHG (the main station of the same company) which operates on 316 meters.

A description of this mobile pick-up

RADIO RELAY STATION

station is of interest to the radio fan for it clears up the "mystery" of this type of broadcasting.

There are four essential links in the chain from the event to the listener.

First, the signal is broadcast by mobile station WGMU on a wavelength of 63 meters.

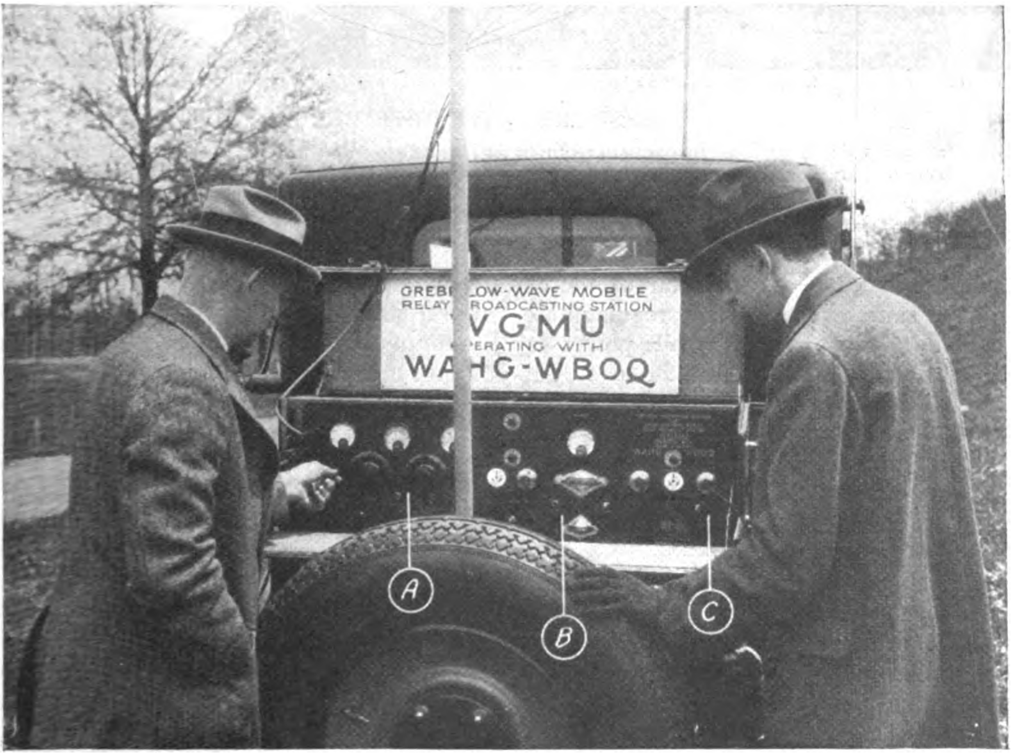
Second, it is picked up by a special short-wave receiver which operates a loudspeaker.

Third, by placing the microphone of WAHG near the above loudspeaker, the signal from the short-wave pick-up station is re-broadcast on a normal wavelength.

Fourth, it is received by the broadcast listener.

In this article only the apparatus used in bringing the signal up to the microphone of the main station, WAHG, is described as the reader is no doubt familiar with the regular broadcasting station. These two links of the chain are the short-wave transmitter and the short-wave receiver.

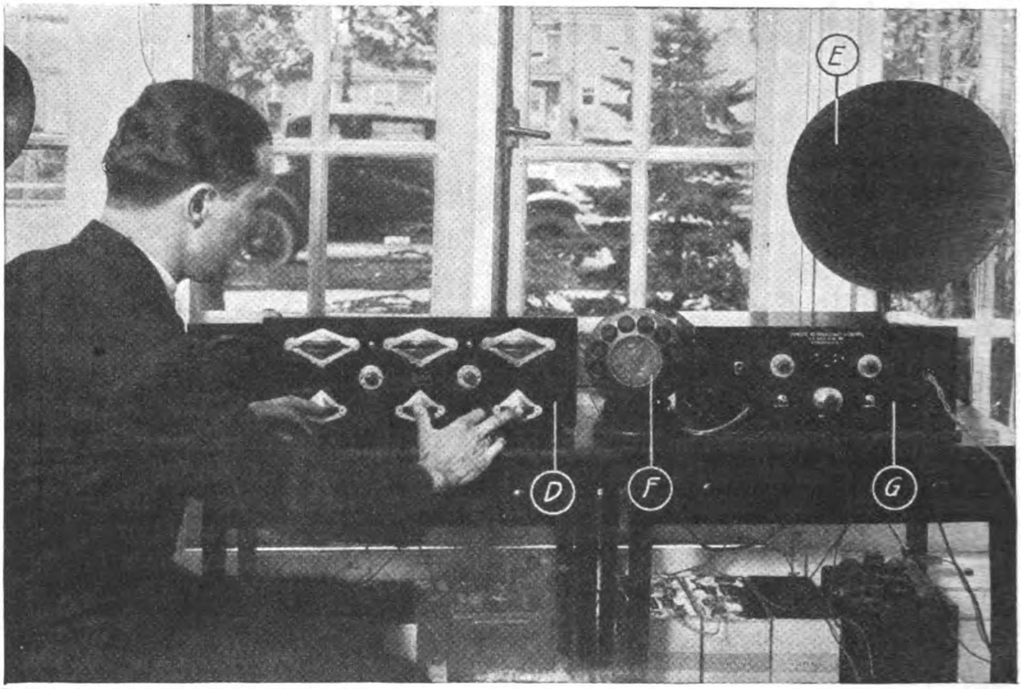
The Grebe short-wave transmitter, WGMU, is installed complete on an automobile but, at the same time, the whole seating capacity of the car is reserved for the station operator and other passengers. The transmitter proper is



From a photograph made for POPULAR RADIO

A SHORT-WAVE TRANSMITTER IN ITS CARRYING CASE

FIGURE 3: *The staff inspects the transmitting apparatus. The designations show A, the transmitter; B, the wave-meter and C, the portable microphone control. The case containing this instrument folds up, thus protecting it from dust and dirt.*



From a photograph made for POPULAR RADIO

THE SHORT-WAVE RECEIVER

FIGURE 4: *The four instruments shown in this photograph are D, a short-wave receiver; E, the loudspeaker; G, the speech amplifier; F, microphone. The receiver picks up the signal from the mobile station and it is made audible through the loudspeaker, picked up by the microphone F and strengthened by the amplifier G.*

carried in a case on the rear of the car in the same manner as the regular automobile trunk is carried, while power for operation of the mobile station is furnished by storage batteries on the running board of the car. (See Figure 1 and the frontispiece for views of the mobile station ready for traveling and set up for operation; also Figure 3 for a closer view of the transmitter.)

The transmitter (shown as A in Figure 3), is a standard vacuum tube type which uses four fifty watt vacuum tubes just as the larger broadcasting stations might use four two hundred and fifty watt tubes. Two additional speech amplifying tubes of a smaller variety are used to strengthen the signal before it reaches the transmitting tubes proper. Storage batteries are used to light the filaments of the vacuum tubes and also to drive a motor generator set which furnishes the 1,500 volt supply for the plate circuit of the transmitting tubes. This motor generator is mounted on springs in a compartment directly under the transmitter. The plate supply for the speech amplifying tubes is furnished by three large size 45 volt "B" batteries.

The antenna is carried just above the roof of the car when running or for short distance work, but it can be raised by means of extension poles to give the transmitter additional broadcasting range. The ground wire is carried to the frame of the car which acts as a counterpoise.

The small panel (shown as B in Figure 3) is a wavemeter which makes it a simple matter for the operator to keep his transmitter on the correct wavelength. It might be mentioned here that the wavelength of 63 meters is one of those set aside by the government for this class of relay work.

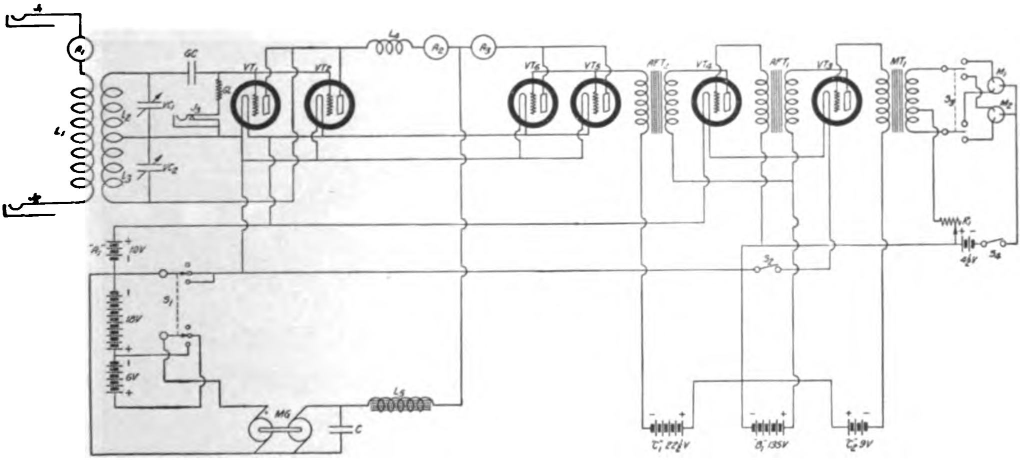
The portable microphone control (shown as C in Figure 3) is an essential part of the transmitting equipment when broadcasting is to be done at some distance from the car. This cabinet may be carried to the scene of the broadcasting, as it is connected back to the car with an extension cable. Microphones are provided for the broadcaster and for the announcer and there is one stage of vacuum tube amplification to insure the signal reaching the transmitter on the car with sufficient strength.

The short-wave receiver which operates in conjunction with mobile transmitter WGMU is a standard Grebe Synchrophase with the coils rewound for the shorter wavelength required. In Figure 4 it is shown as D together with the loudspeaker E which it operates.

The microphone of station WAHG is indicated as F and it is placed in about the position shown rather than directly in front of the loudspeaker of the short-wave receiver. As the particular microphone of station WAHG shown in Figure 4 is located in Mr. Grebe's home, the signal is sent through the amplifier G before it is transmitted by wire to station WAHG.

A complete test and demonstration of the satisfactory operation of mobile station WGMU was carried out by the technical staff of Popular Radio as follows: The mobile station was run to an isolated point, approximately twenty miles out on the Long Island Motor Parkway, and there put in operation as shown in the frontispiece. We could now talk back to the operator of the short-wave receiver (see Figure 4) and we gave instructions to put our voices on the air through station WAHG. We were now broadcasting from station WAHG, but we had no check on just what was being sent out.

The car in the background (in the frontispiece) supplied this check, as it contains an ordinary receiving set such as any broadcast listener would use. As soon as this receiver was tuned to WAHG the loudspeakers on the running board reproduced everything which we spoke into the microphone. Thus the signal had made a trip back to WAHG on a



THE CIRCUIT DIAGRAM FOR THE TRANSMITTER

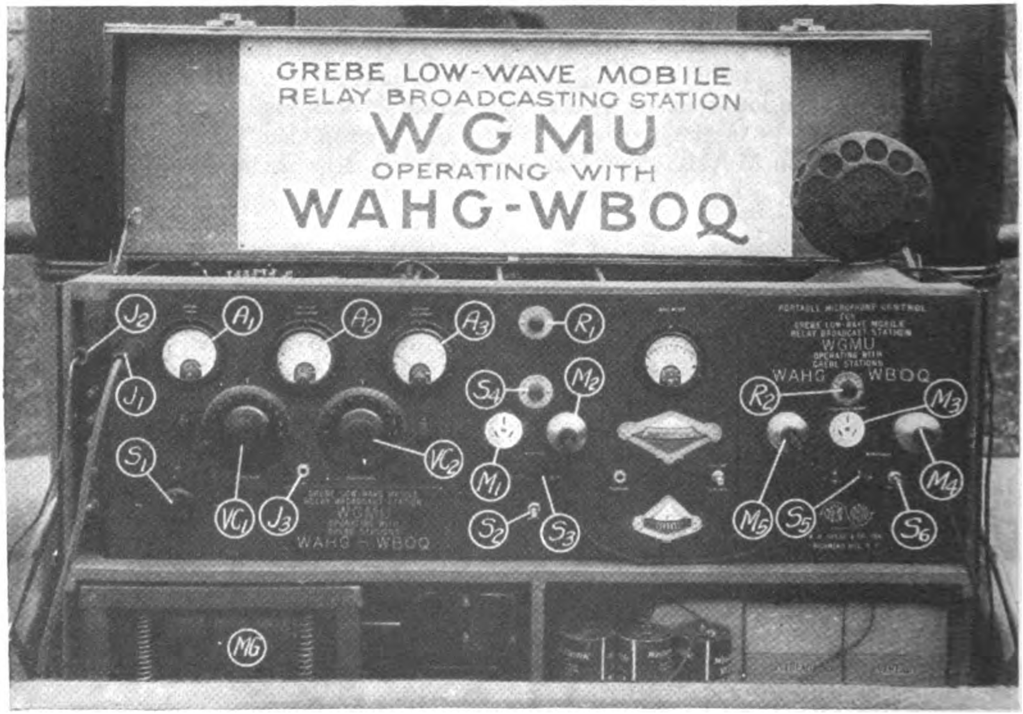
Figure 5: *This diagram shows the general electrical connections for the microphone circuit, the speech amplifier, the modulator tubes and the short-wave oscillator tubes. The two jacks, J1 and J2 are connected to the short antenna and to the frame of the car, which act as the antenna and counterpoise respectively.*

wavelength of 63 meters and a return trip to the receiving car on a wavelength of 316 meters.

A pick-up station such as WGMU can be used as a relay from any point to which an automobile can be driven. The same type of station installed on a launch can be used to relay descriptions of aquatic events. On an airplane it would serve in the same manner for bird's-eye descriptions of races and such events. Thus much closer contact with current events is possible by radio than would have been dreamed of a few years ago.

For some of the technical details of the transmitter that are of interest to the more rabid fans, consult Figure 5 for a complete wiring diagram of the transmitter and Figure 6 for a panel view of the transmitter with the instruments marked by the same designating letters used in the schematic diagram. The circuit used is a modified Hartley circuit with separate grid and plate tuning for the oscillator tubes. Heising modulation is employed.

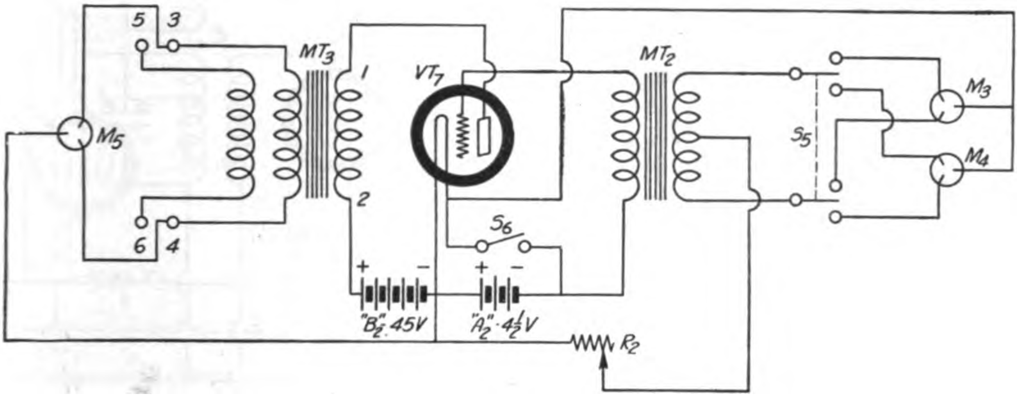
Two fifty-watt vacuum tubes VT1 and VT2 are operated in parallel as oscillators. The grid circuit of these tubes consists of the inductance L2, the tuning condenser VC1, the .002 mfd. grid condenser GC, the 10,000 ohm grid leak GL and the jack J3, the latter to insert a key for continuous wave work. The plate circuit of these tubes consists of the inductance L3, the tuning condenser VC2, the radio-frequency choke L4, the plate-current milliammeter A2, the 1,500-volt generator of the motor-generator MG and the filter system which is a 30-henry choke L5 and a 3-mfd. condenser C. Switch S1 provides an "off" position, also high and low-



From a photograph made for POPULAR RADIO

A CLOSEUP OF THE SHORT-WAVE TRANSMITTER

FIGURE 6: *This picture gives a detailed view of the transmitting oscillator panel, the wave-meter and the microphone control panel. The various designations drawn in the photograph tell in the text exactly what each instrument is.*



THE DIAGRAM OF THE MICROPHONE CONTROL

FIGURE 7: *The electrical connections for the microphone receptacles, the transformers and the vacuum tubes that are employed for picking up the signal and supplying it with the proper strength to the transmitter located at the rear of the motor car.*

power positions by changing the voltage on the driving motor of the motor-generator-unit.

The microphone circuit consists of microphone receptacles M1 and M2, microphone changeover switch S3, cutoff switch S4, a 4½-volt battery, rheostat R1 and the primary of modulation transformer MT1. Instead of the secondary of the modulation transformer acting directly on the modulator tubes, the voice-frequency current is passed through two stages of amplification, consisting of vacuum tube VT3, audio-frequency transformer AFT1, vacuum tube VT4 and audio-frequency transformer AFT2 together with the necessary batteries. The grid circuit of the fifty-watt modulator tubes VT5 and VT6 contains the secondary of transformer AFT2 and a 22½-volt "C" battery. The modulator tubes receive their plate current from the same 1,500-volt generator as the oscillator tubes but it passes through the plate milliammeter A3 instead of A2.

The filaments of all the tubes in the transmitter are lighted by the 10-volt storage battery A1. Those of the small speech-amplifier tubes VT3 and VT4 are connected in series and provided with a cutoff switch S2.

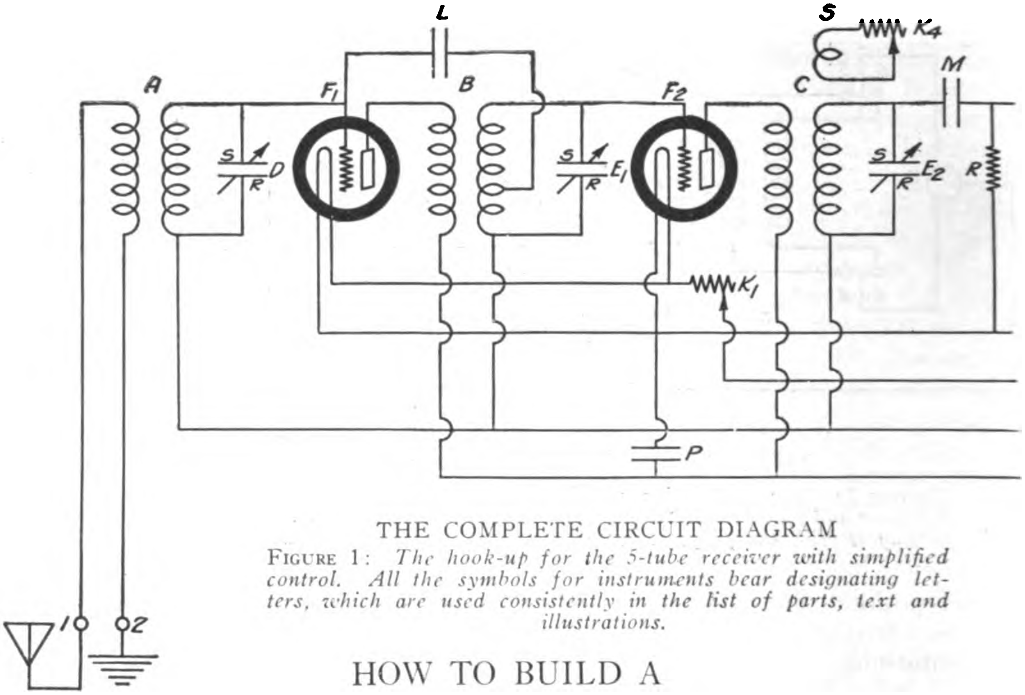
The antenna circuit of the transmitter consists of the antenna jack J1, the antenna ammeter A1, the inductance L1 and the counterpoise jack J2.

Refer to Figures 6 and 7 for the details of the portable microphone control. The microphone circuit embraces the microphone receptacles M3 and M4, the microphone changeover switch S5, the primary of the modulation transformer MT2, the rheostat R2, the 4½-volt battery and the cutoff switch S6.

The secondary of the modulation transformer works through one stage of amplification, consisting of VT7 with its necessary batteries, into the primary of modulation transformer MT3. Either the high-ratio secondary (terminals 5 and 6) or the low-ratio secondary (terminals 3 and 4) of this transformer may be connected to the output receptacle M5. This latter receptacle is connected by flexible cable to either microphone receptacle M1 or M2 of the transmitter.

This covers fairly thoroughly the design and operation of an ideal short-wave relay installation.

With the growing use of mobile pick-up stations of this type, located on automobiles, airplanes, launches, trains or ocean-going steamships there will be no single spot left in the future on the land, in the air or on the sea from which a broadcast program may not originate.



THE COMPLETE CIRCUIT DIAGRAM

FIGURE 1: *The hook-up for the 5-tube receiver with simplified control. All the symbols for instruments bear designating letters, which are used consistently in the list of parts, text and illustrations.*

HOW TO BUILD A

5-Tube Radio Frequency Set

—with Simplified Control

The set here described is particularly recommended because it will not radiate—even though it uses regeneration. Operation has been simplified by using a minimum of panel controls. A special type of amplification has been used to give distortionless reproduction.

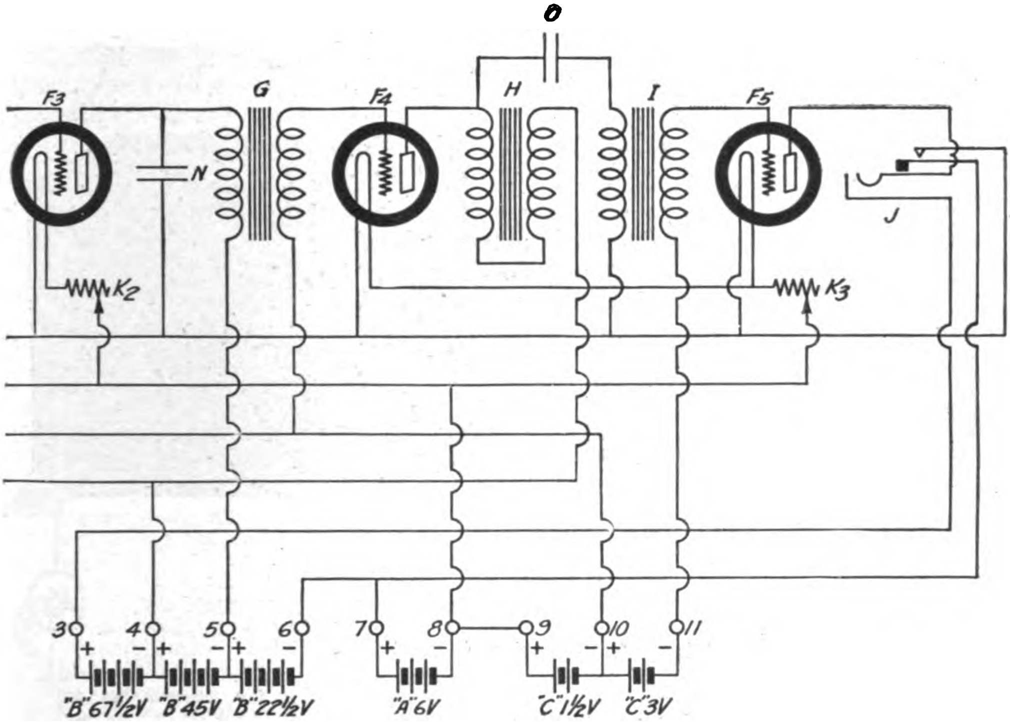
By ALBERT G. CRAIG

COST OF PARTS: *Not more than $65.00*

RECEIVING RANGE: *Up to 2,000 miles*

HERE ARE THE ITEMS YOU WILL NEED—

A, B and C—Aero Coil low-loss tuning inductance and two radio-frequency transformers;
D—Lombardi straight-line frequency variable condenser, .00035 mfd.;
E—Lombardi straight-line frequency double variable condenser, .00035 mfd. capacity for each half;
F1, F2, F3, F4 and F5—Benjamin standard sockets;
G—Rauland-Lyric audio-frequency transformer;
H—Thordarson audio-frequency transformer ratio 6 to 1;
I—Thordarson audio-frequency transformer, ratio 3½ to 1;
J—Carter last-stage filament control jack, No. 103;
K1, K2, K3 and K4—Bradleystats;
L—X-L Vario Denser, Model N;
M—Sangamo mica fixed condenser, .00025 mfd.;
N—Sangamo mica fixed condenser, .002 mfd.
O—Dubilier micadon, type 640, .02 mfd.;
P—Dubilier by-pass condenser, 1. mfd.;
Q—Daven resistance mounting;
R—Daven resistance unit, 5 megohms;
S—Loop around radio-frequency transformer C;
T—composition panel, 7 by 24 inches;
U—hardwood sub-base, 9⅞ inches by 23 inches;
V—antenna binding post strip;
W—battery binding post strip;
X—small brass brackets;
Y—cabinet;
machine screws; wood screws; bus wire.



THIS receiving set was designed with three essential requirements always in mind. First, it must be simple to control. Second, it must not radiate. And third, it must give quality reproduction.

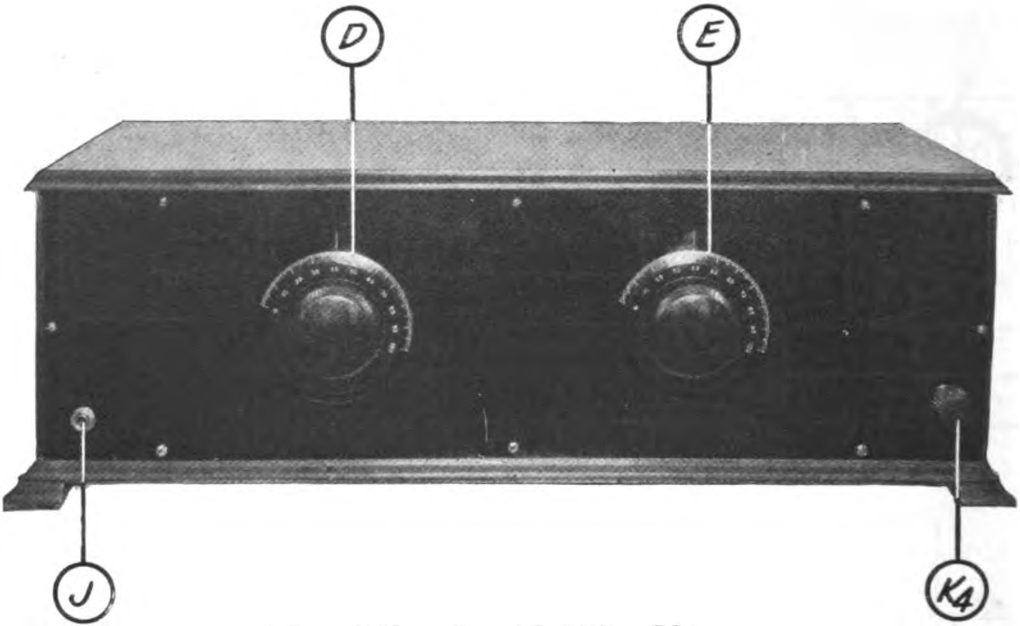
An important step toward easier tuning was made possible by the commercial development of the multiple condenser. By using a single condenser for the tuning inductance and a two unit multiple condenser (that is, two condensers on the same shaft) for the two radio frequency transformers, the number of wavelength controls was reduced from three to two, or the maximum number which one person can move simultaneously.

All of the variable condensers in this set are the straight line frequency type, which change the frequency to which the circuit is tuned uniformly as the dial is rotated. As the broadcasting station wavelengths are assigned with uniform frequency differences between them, this means that they will be separated equally on the tuning dials. With the ordinary condenser it will be noticed that the low wavelength stations seem to be crowded together while there is more space than necessary between the high wavelength stations.

Three filament rheostats have been employed, one for the two radio-frequency tubes, one for the detector and one for the two audio-frequency tubes, but all of these rheostats have been placed within the set as their adjustment is not critical, and it is just as well to remove the temptation to turn them continuously. All tube filaments are lighted by inserting the loudspeaker plug in the single filament control jack.

This receiving set has been made non-radiating by neutralizing the grid-plate capacity of the first radio frequency tube, but at the same time the sensitivity of the receiver to weak signals has been increased considerably by providing a variable regeneration control over the second radio frequency tube. An absorption loop around the second radio-frequency transformer, with a Bradleystat for varying the absorption effect, worked out to give an easy control over regeneration.

To test the receiver for radiation, the



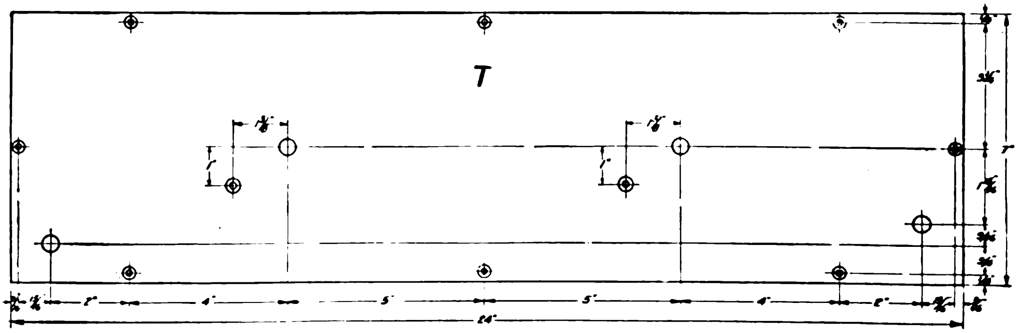
THE PANEL VIEW OF THE RECEIVER

FIGURE 2: *This gives an idea of how the set looks from the front. As the dials and knobs are marked with letters which correspond with the instruments to which they are attached, the prospective operator will have no trouble in locating the various controls as they are explained in the instructions for tuning.*

second radio-frequency tube was made to oscillate and heterodyne with a certain broadcasting station. At the same time a second set across the laboratory was tuned to the same broadcasting station and the program was received with no trace of a whistle from the first set.

A special type of amplification has been chosen which gives, in effect, the quality of choke coil amplification with the voltage step-up (for greater volume) of transformer-coupled amplification. Because suitable choke coils are not generally available commercially, one audio-frequency transformer has been utilized as a choke coil by connecting the two windings in series and a second audio-frequency transformer used for its regular purpose as a voltage step-up device.

This receiver was tested on antennas



THE DRILLING PLAN FOR THE PANEL

FIGURE 3: *Where to drill the holes for mounting the instruments. The holes outlined with a double circle should be countersunk. Always start drilling holes in the panel with a small drill; one-sixteenth inch is a desirable size.*

which varied in length from 10 to 150 feet. On the local New York stations good volume and excellent selectivity were obtained on the shortest antenna while the distance possibilities were increased as the antenna was lengthened. A good average length of antenna would be 75 feet.

The schematic diagram of Figure 1 will give a good conception of the circuit that is employed.

Parts Used in Building the Set

In all the diagrams in this article each part bears a designating letter; in this way, the prospective builder of a set may easily determine how to mount the instruments in the correct places and connect them properly in the electric circuit.

The same designating letters are used in the text and in the list of parts at the beginning of the article.

¶ *The list of parts there given includes the exact instruments used in the set from which these specifications were made up. The experienced amateur, however, will be able to pick out other reliable makes of instruments which may be used with equally good results. But we recommend that the novice follow the list, as the diagrams in this article will tell him exactly where to bore the holes and exactly where to place the connections.*

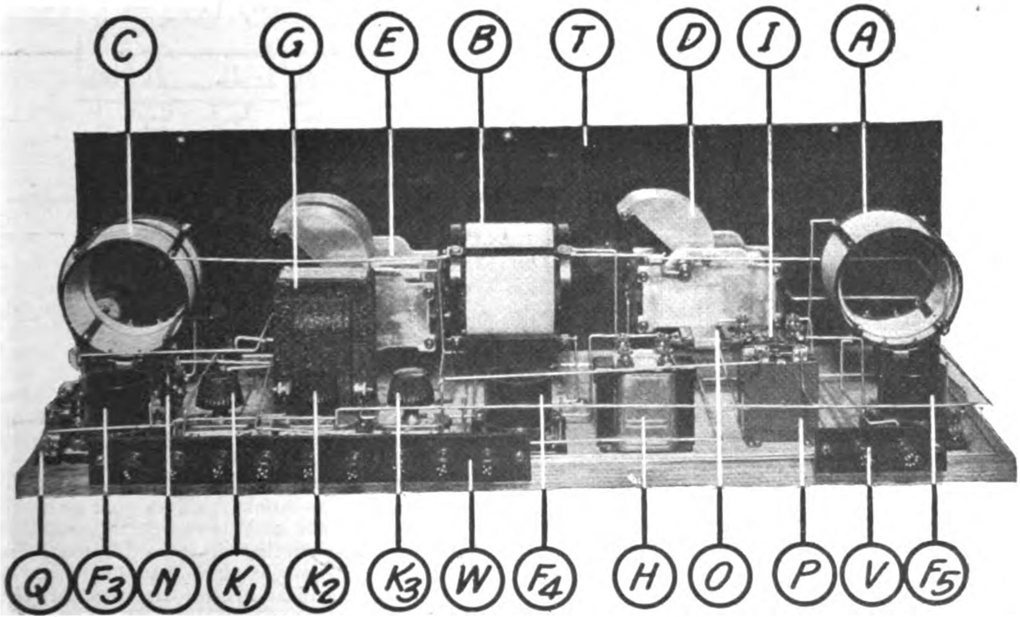
If instruments other than the ones listed are used, the only change that will be necessary will be the use of different spacings for the holes that are to be drilled in the panel for mounting the instruments.

How to Construct the Set

After procuring all the instruments and materials for building the set, the amateur should prepare the panel T (shown in Figures 2, 3 and 4).

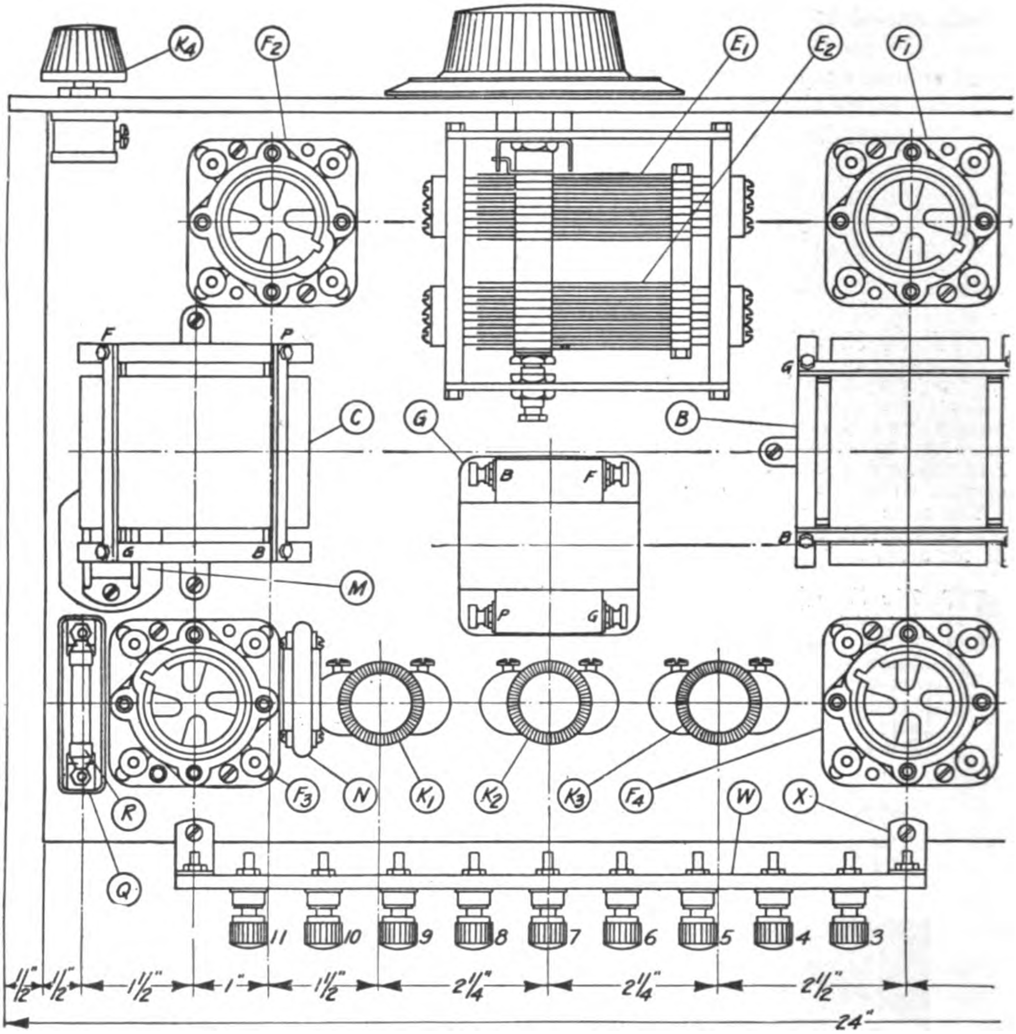
First, cut the panel to the correct size, 7 by 24 inches. Then square up the edges smoothly with a file. The centers for boring the holes (which are necessary for mounting the instruments) should be laid out on the panel as shown in Figure 3. A convenient method of doing this is to lay out all center holes on a piece of paper the same size as the panel; then the piece of paper should be pasted on the panel and the centers marked directly on the panel by punching through the paper.

The holes outlined with a double circle should be countersunk, so that the flat-head machine screws used for fastening the instruments are flush with the panel. All the rest of the holes in the panel are straight drill holes. Sizes for the diameters of these holes have not been given, but the builder will



VIEW OF THE SET FROM THE REAR

Figure 4: *This picture shows the general arrangement of all the instruments fastened to the panel or base. The exact locations for the instruments are shown in Figure 5.*



THE WORKING DRAWING FOR CONSTRUCTION

Figure 5: *Here are shown the correct positions for the instruments which are mounted on the base. The positions are given, center to center, for all instruments.*

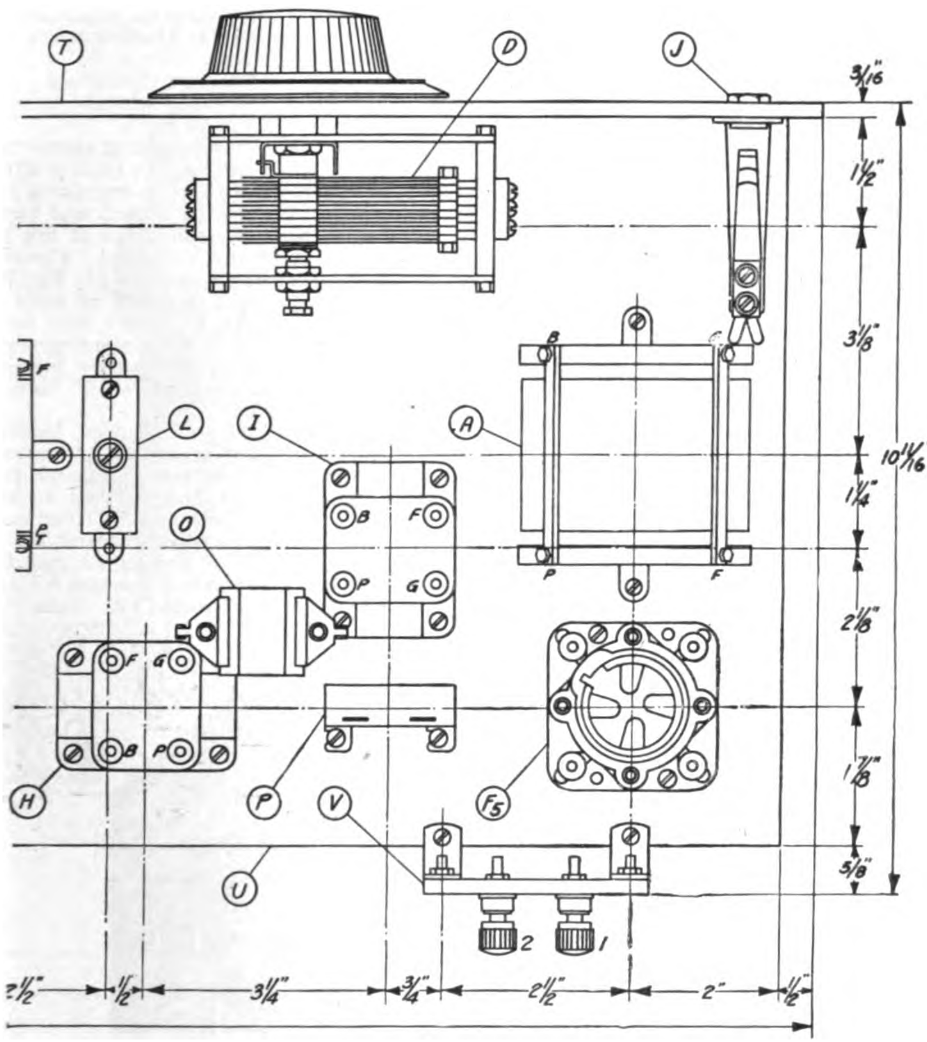
readily decide what size hole is necessary by measuring the diameters of the screws and shafts of the instruments that must go through the holes.

When the panel is drilled, the builder may give it a dull finish by rubbing the face of the panel lengthwise with fine sandpaper until it is smooth. This process should be repeated, except that light machine oil should be applied during the second rubbing. Then rub the panel dry with a piece of cheesecloth. A permanent dull finish will be the result. Or the panel may be left with its original shiny-black finish, if care is exercised so that it is not scratched during the drilling.

The sub-base U (see Figures 4 and 5) should be cut to size 9⅞ by 23 inches. If a piece of ½-inch hardwood, surfaced on both sides, can be obtained the work of squaring up the edges will be a minimum.

Make up the composition antenna binding post strip V, the battery binding post strip W and also the four small brass brackets X, if these cannot be purchased. (See Figure 8 for detailed dimensions of these parts.)

Complete specifications for constructing the cabinet Y are shown in Figure 10. It may be made out of ½-inch hardwood such as mahogany, walnut or oak, and finished to suit the taste of the builder. Or the cabinet may be purchased from your radio dealer as it is a standard size. In the latter case it will only be



necessary to cut the slots in the back of the cabinet for the binding post strips.

Preliminary to mounting the parts of the set fasten the panel T at right angles to the sub-base U with wood screws driven through the panel holes into the edge of the sub-base. (See Figures 4, 5, 6 and 7.)

Beginning with the base-mounted instruments, fasten the sockets F1, F2, F3, F4 and F5 to the sub-base with wood screws in the positions shown in Figures 4 and 5. Note the positions of the socket slots from Figure 5.

By means of two wood screws through the metal eyelets, fasten the neutralizing condenser L to the base as shown in Figure 5. The metal terminal which comes straight out of the bakelite case should be towards the rear of the set.

Mount the three audio-frequency transformers G, H and I according to Figures 4 and 5. The plate and grid terminals of G are towards the rear of the set; the positive "B" and plate terminals of H are towards the rear of the set and the plate and grid terminals of I are towards the rear of the set.

Using fine wood screws, mount the three rheostats K1, K2 and K3 on the sub-base with the terminal towards the rear of the set. Note the exact positions from Figures 4 and 5.

Fasten the bypass condenser P to the sub-base as shown in Figures 4 and 5.

Fix the resistance mounting Q in position beside socket F3. (See Figures 4, 5 and 7.)

Prepare the tuning inductance A and the two radio-frequency transformers B and C for mounting by attaching the small supporting brackets furnished with these coils. Mount the tuning inductance A, which is the coil with only four soldering terminals, with the terminals marked F and P towards the rear of the set. (See Figures 4, 5 and 6.) Mount the radio-frequency transformer B with the terminals marked B, T and P towards the rear of the set. (See Figures 4 and 5.) Mount the radio-frequency transformer C with the terminals marked B and G towards the rear of the set. (See Figures 4, 5 and 7.)

Assemble the eleven binding posts on panels V and W and fix these two binding post panels to the sub-base by means of the four small brass brackets X. Note the positions of these binding post strips from Figures 4 and 5.

Starting on the panel, mount the jack J with the frame down in the lower left-hand corner of the panel according to Figures 5 and 6.

Now, fasten the regeneration control K4 in the lower right-hand corner of the panel, noting that the terminals are turned inward. (See Figures 5 and 7.)

Finally, mount the two variable condensers D and E on the panel. The correct positions are shown in Figures 4 and 5. Attach dials to these condensers.

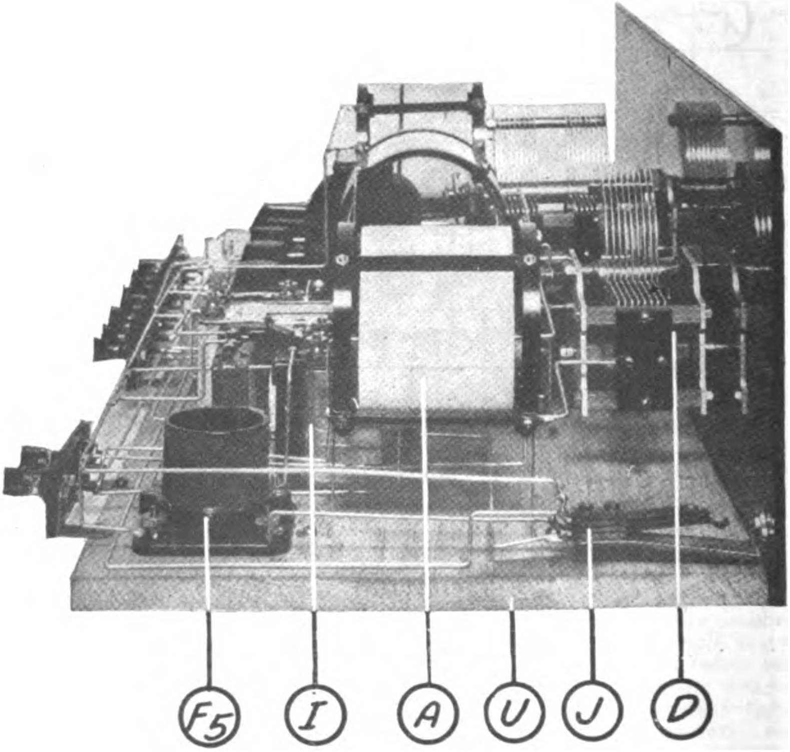
How to Wire the Set

When wiring, it should be remembered that all connections from the high-voltage side of the transformers and coils (that is to say the side next to the vacuum tubes) should be kept about ½-inch away from the other wiring and should not run parallel to other wires for any considerable distance.

Use tinned-copper bus wire throughout. All connections should be bent into the proper shape and then soldered in place.

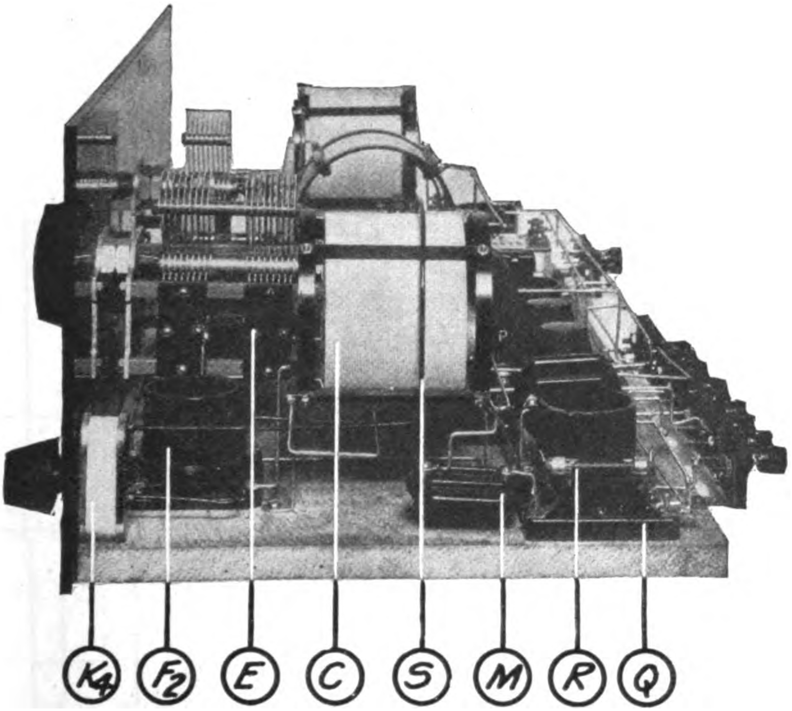
Start wiring the filament-lighting circuit according to Figures 1 and 9. The main positive and negative filament bus wires run along the rear of the set between the sockets and binding post strips and along the front of the set between the sockets and the panel. Connect the positive terminals of sockets F1, F2, F3, F4 and F5 together and continue the wire to the top terminal of jack J. Run a wire from the second terminal of jack J (counting from the top) to the negative "B" battery binding post (No. 6) and to the positive "A" battery binding post (No. 7).

Connect the positive "C" battery binding post (No. 9) and the negative "A" battery binding post (No. 8) to the right-hand terminals of rheostats K1 and K2 and to the left-hand terminal of rheostat K3. Now, connect the left-hand terminal of rheostat K1 to the negative terminals of sockets F1 and F2. Join the left-hand terminal of rheostat K2 and the negative terminal of socket F3. Next, run



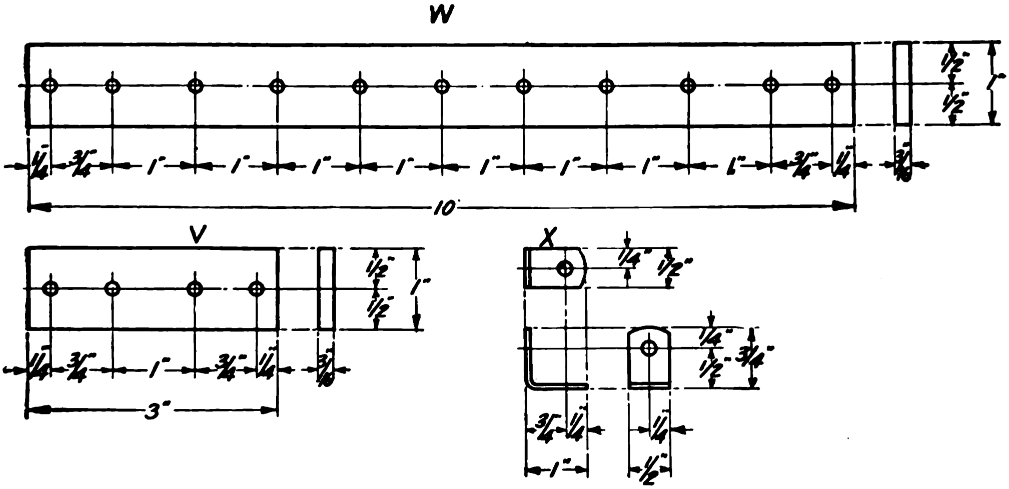
VIEW OF THE SET FROM THE LEFT

FIGURE 6: *This illustration shows the general manner of mounting the tuning inductance and its condenser, the jack, the last socket and the antenna binding post strip.*



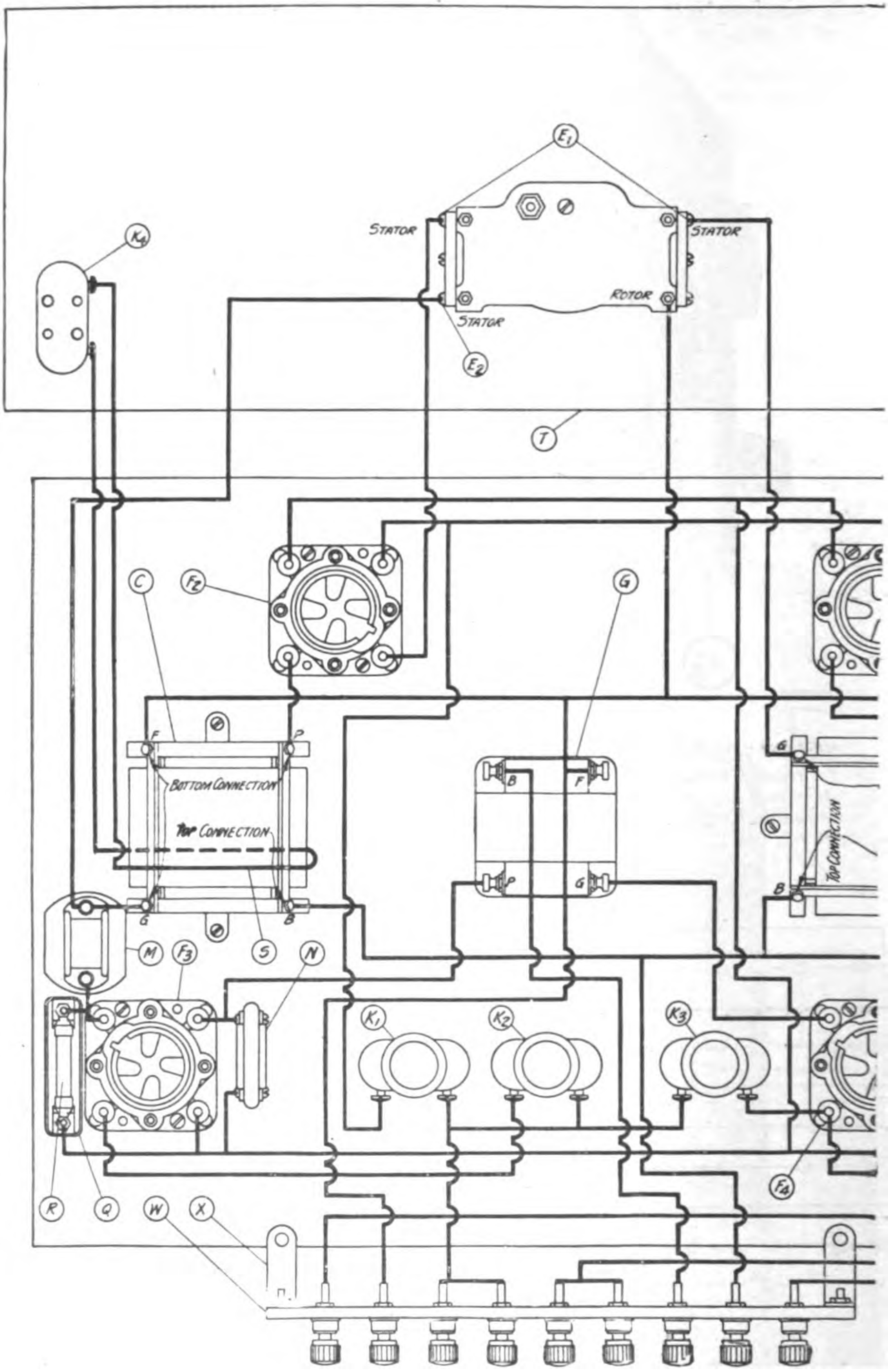
HOW THE SET LOOKS FROM THE RIGHT

FIGURE 7: *This end view indicates the manner of mounting the last radio-frequency transformer, the grid-leak, the grid-condenser, the battery binding post strip and the regeneration control which consists of a single turn of insulated wire around the radio-frequency transformer and a rheostat connected to the ends of the single turn.*



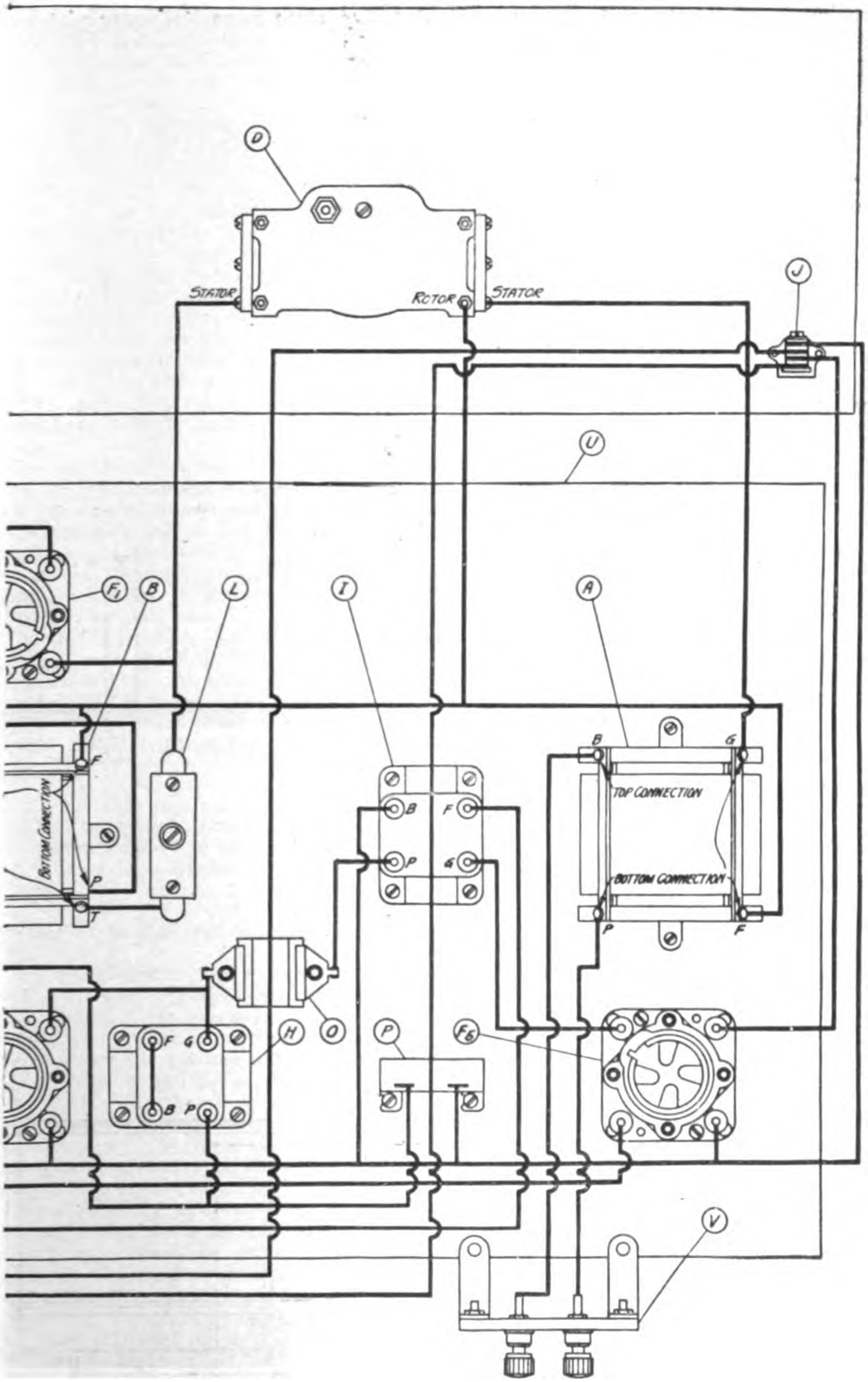
DETAILS OF THE CONNECTION BLOCKS AND THE SMALL BRASS BRACKETS

FIGURE 8: *This drawing gives the necessary data for making the insulating strips on which the binding posts are mounted. It also gives the dimensions for the small brass brackets that are used to fasten the strips to the base.*



THE WORKING PLAN FOR

FIGURE 9: *The upper rectangle represents the panel, and on it the instruments are drawn just as they appear. The lower rectangle represents the base; the instru-*



CONNECTING UP THE INSTRUMENTS
ments are drawn in approximately the positions they would have when seen from above. The heavy black lines show the way to wire up the mounted instruments.

a wire from the right-hand terminal of rheostat K3 to the negative terminals of sockets F4 and F5.

Now, connect the terminal marked P on the tuning inductance A to the antenna binding post (No. 1). Connect the terminal marked B on the same coil to the ground binding post (No. 2).

Join the terminal marked G on the tuning inductance A to the stationary plates of condenser D. Also connect the stationary plates of condenser D, the grid terminal of socket F1 and the nearest terminal of the neutralizing condenser L.

Next connect the terminals marked F on tuning inductance A, on radio-frequency transformers B and C, on audio-frequency transformer G with the rotary plates of condensers D and E and continue the wire to the negative "C" battery binding post (No. 10).

Join the plate terminal of socket F1 and the terminal marked P on the radio-frequency transformer B.

Now, connect the terminals marked B on radio-frequency transformers B and C, the plate binding post of audio-frequency transformer H, the nearest terminal of condenser P and the positive "B" battery binding post (No. 4). Join the remaining terminal of bypass condenser P to the wire connecting the positive socket terminals.

Join the terminal marked G on the radio-frequency transformer B to the stationary plates of section E1 of the multiple condenser. Also connect these same stationary plates of E1 to the grid terminal of socket F2. Connect the terminal marked T of radio-frequency transformer B to the open terminal of neutralizing condenser L.

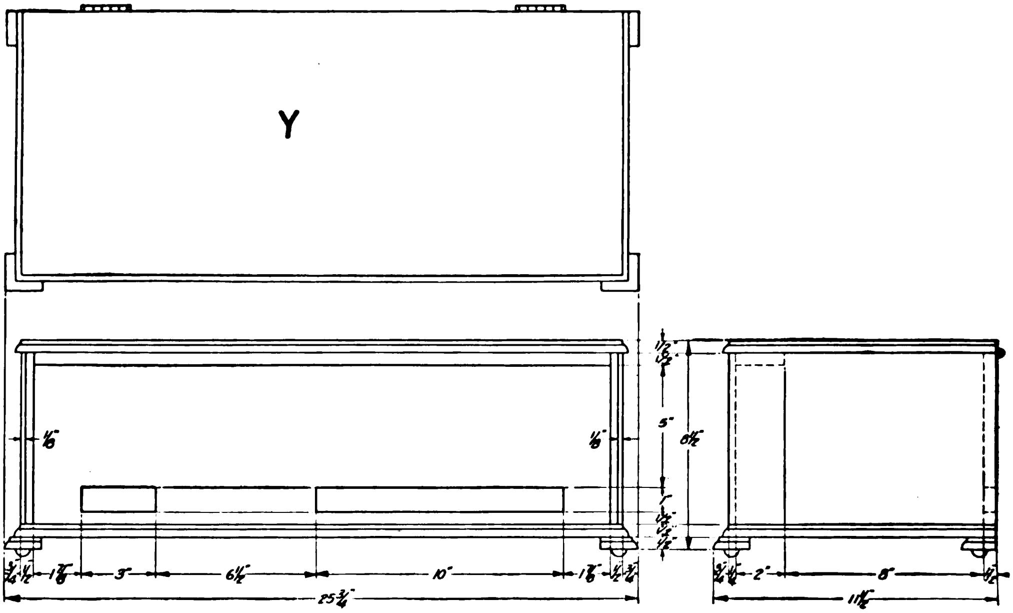
Now join the plate terminal of socket F2 and the terminal marked P on the radio-frequency transformer C.

Connect the stationary plates of section E2 of the multiple condenser, the terminal marked G on the radio-frequency transformer C, and one terminal of the grid condenser M. Join the other side of the grid condenser M, the adjacent terminal of the grid-leak mounting Q and the grid binding post of socket F3. Connect the remaining terminal of the grid-leak mounting to the wire joining the positive socket terminals. Insert the grid-leak R in its mounting. (See Figure 7 for the position of the grid condenser.)

Place a single turn of insulated bus wire around radio-frequency transformer C and connect its ends to the two terminals of the regeneration control K4. (See Figures 4, 5 and 7 for the placing of this loop.)

Next, connect the plate terminal of socket F3 with the plate terminal of audio-frequency transformer G and with one side of the condenser N. Connect the other side of condenser N to the wire joining the positive socket terminals. Join the terminal marked B on transformer G to the positive "B" battery detector binding post (No. 5).

Connect the terminal marked G on trans-



THE DIMENSIONS FOR THE CABINET

FIGURE 10: *This diagram (which gives the top, front and side measurements for the cabinet) may be turned over to a competent cabinet maker who can build a cabinet from these directions so that it will fit the set correctly.*

THE RECEIVER WORKING ON A TEN-FOOT ANTENNA IN THE LABORATORY TEST

No difficulty was experienced in getting good loudspeaker reception on the local broadcasting stations with very short antennas. Under these conditions the regeneration control is the main factor in bringing the signal up to loudspeaker volume. It is also useful in increasing volume from distant stations when using longer antennas.

former G to the grid binding post of socket F4.

As transformer H is to be used as a choke coil, join the negative filament and positive "B" binding posts together. Connect the plate terminal of socket F4, the grid binding post of transformer H and one side of condenser O. See Figures 4 and 5 for the position of condenser O. Join the other side of condenser O and the plate binding post of audio-frequency transformer I. Connect the positive "B" binding post of transformer I to the wire joining the positive socket terminals.

Now join the grid binding post of transformer I and the grid terminal of socket F5. Run a wire from the negative filament binding post of transformer I to the negative "C" battery binding post (No. 11).

Connect the plate terminal of socket F5 to the third terminal of jack J. Finally, connect the bottom terminal of jack J to the positive amplifier "B" battery binding post M (No. 3).

The set should now be completely wired.

How to Install the Set

After the set has been completely wired, place it in the cabinet and fasten with wood screws through the holes provided at the edges of the panel.

The antenna panel and the binding post panel will now fit into the slots in the back of the cabinet and will come approximately flush with the back of the cabinet.

Attach the antenna lead-in wire to binding post No. 1 (the first one on the right, looking at the rear of the set). Connect the ground wire to binding post No. 2. Connect the "A," "B" and "C" batteries according to the diagram of connections given in Figure 11.

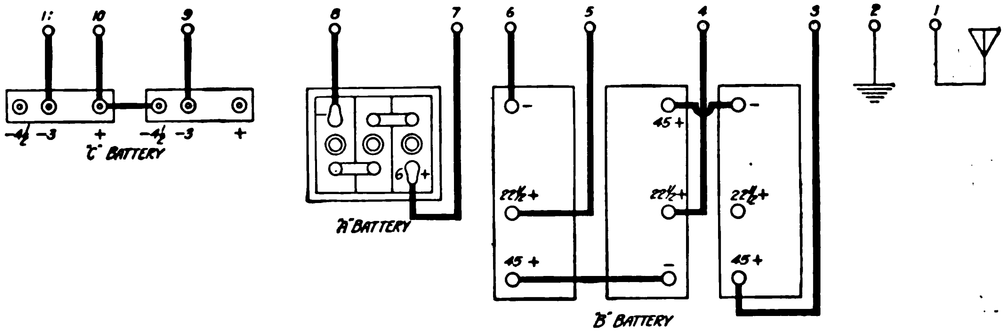
Turn the adjusting screw of the Vario Denser L counter-clockwise until the tension on the screw is released, indicating minimum capacity. The minimum capacity of this condenser is approximately correct for a 201-a tube and will serve as a trial setting.

Insert five UV-201-a or C-301-a in the five sockets F1, F2, F3, F4 and F5. Insert the loudspeaker plug in jack J and turn up the rheostats K1, K2 and K3 until all five tubes are lighted to the ordinary brilliancy.

The set is now ready for use.

Operating Data

The regeneration control K4 should be



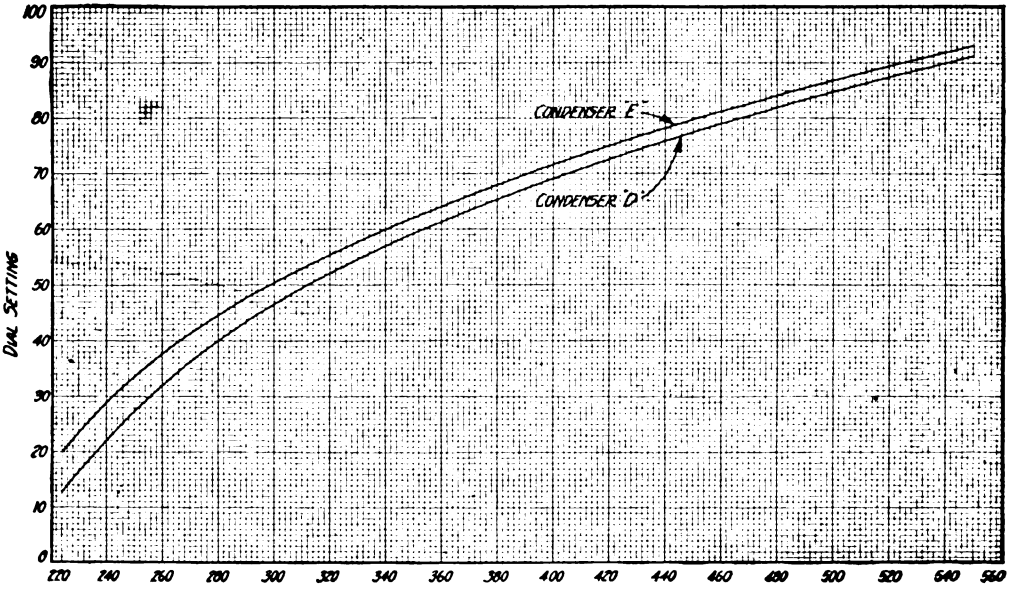
THE CONNECTIONS TO THE BINDING POST PANELS

Figure 11: *This drawing will prevent you from making mistakes in connecting to the terminals at the back of the receiver. If you follow these instructions, the set will be hooked up correctly as the terminals shown in the wiring diagram are marked with designations that correspond with the numbers given here.*

turned clockwise to the stop position, as its use may be studied better after some station has been tuned in.

The tuning chart of Figure 12 was made up from the laboratory set and should be approximately correct for other sets which have been made up with the same apparatus. Therefore we will use this chart as a starting point. Select the most powerful local broadcasting station and find its wavelength in the newspaper; from this same wavelength at the bottom of the tuning chart run a vertical line up to the curve for condenser D, then run a horizontal line over to the left margin of the chart and read the dial setting for condenser D. Use the curve for condenser E in the same manner and find the dial setting for condenser E. Use these dial settings and find out whether the local station selected is audible or not. If it is, merely adjust each condenser separately until the station is received with the best volume.

If difficulty is experienced in picking up a station, move condenser D slightly off the setting indicated by the chart and slowly rotate condenser E about the chart setting. Repeat



THIS TUNING CHART TELLS YOU HOW TO SET THE DIALS

Figure 12: *This chart gives the dial settings of the two tuning condensers for the broadcasting wavelengths. Your set should tune approximately the same as the laboratory set if the same apparatus is used.*

this process, moving condenser D in small steps, until a station is picked up. Adjust the condensers for greatest volume.

Now the filament rheostats K1, K2 and K3 can be adjusted and left until a drop in storage battery voltage requires a new setting (this should be very seldom if the storage battery is kept well charged). Turn the rheostats down (counter-clockwise) one at a time, until the signal decreases sharply in strength; then turn the rheostats back up slightly. There will be found an adjustment such that turning the rheostats up does not markedly increase the signal strength, but turning them down does decrease it very much. This is the best setting for the rheostats.

To set the neutralizing condenser L, tune in a good strong signal to work on. Remove the first radio-frequency tube from socket F1; run a thin strip of paper down the inside of the socket and over one of the filament prongs; then replace the vacuum tube. It should not light now because of the paper between the tube contact and the socket contact. With a sharpened stick vary the neutralizing condenser L until the original signal is received with minimum strength; this indicates that the grid-plate capacity of the first radio-frequency tube has been neutralized. Phones are good for this adjustment. It may be necessary to vary the tuning condensers slightly during the balancing process.

Now the regeneration control K4 can be tested out; its effect will be more marked if a weak signal is being received or if a local station is being received weakly on a short antenna. Gradually turn the control knob K4 counter-clockwise and notice the signal grow in strength; this will continue until the second radio-frequency tube starts to oscillate, which indicates that you have gone too far. However, the set does not radiate and disturb your neighbors, since the first tube is neutralized and prevents the oscillation from reaching the antenna.

After the receiving set has been adjusted it can be turned off and on by removing and replacing the loudspeaker plugs.

Nine Tips for Summertime Reception

1. Don't try to pick up long distance in midsummer. Be satisfied to enjoy the good programs from the nearer stations.

2. Don't be disappointed if an occasional storm interferes with your summer radio evening.

3. If you want louder signals, use a longer antenna, more tubes, higher plate voltage, more sensitive loudspeakers and more careful tickler and receiver adjustment.

4. A Pleasant signal filling a moderate size room should be enough to give satisfaction. It is wasteful to insist on tremendous signals which generally are less pleasant than moderate signals.

5. If your local station comes in too loudly and drowns others out, a smaller aerial will help in tuning him out, with a small condenser connected between aerial and ground. And if all measures to get rid of the local station fail, why not enjoy his concerts?

6. For the longer waves above 450 meters, use a condenser connected between the aerial and ground terminals of your set.

7. Read Popular Radio. It helps you to know how your set works and keeps you up to date in radio. Information of this sort is an aid in getting the concerts loud and clear.

8. Ask your radio dealer for advice; he can probably tell you what you want to know and will be glad to do so. The manufacturer of your set is also willing to help you get the desired results from its use.

9. Do not throw away the direction sheets or booklet that came with your set and with the tubes. Read all such material carefully now and then, and follow the suggestions which are given. If you have lost the direction sheets write to the dealer or manufacturer for another copy. The direction sheets answer most of the questions which have been puzzling you and preventing you from getting the best out of your set.

"What Set Shall I Buy?"

A LITTLE more than a year ago there were only a very few ready-made sets on the market. Today there are about 140, ranging from small and inexpensive crystal receivers, which sell for as low as four or five dollars, to elaborate superheterodynes that run into the hundreds. Those that have been approved by the POPULAR RADIO LABORATORY will be pictured each month until the series is completed. They will be accompanied by brief but specific and authoritative data concerning them—as a helpful guide to the broadcast listener and to the prospective listener who is thinking of selecting the receiver that will best meet his special needs as well as the limitations imposed by his purse.

Operadio Convertible Receiver

This receiver may be taken out of the cabinet and carried with you on your vacation. It is equipped with a handle and cover.

Manufacturer's Name; The Operadio Corp.

Model; Portable 1925 Operadio

Number of Tubes; six

Type of Tuning; tuned radio frequency

Type of Detector; vacuum tube

Range on Phones; 3,000 miles (9,000 mile record)

Range on Loudspeaker; 3,000 miles (9,000 mile record)

Complete Cost; $189.00

Antenna Recommended; self-contained loop

Kind of Tubes for R. F.; 199 type

Detector Tubes; 199 type

Audio Tubes; 199 type

Type of "A" Battery; six 1½-volt dry cells

Type of "B" Battery; four 22½-volt dry cells

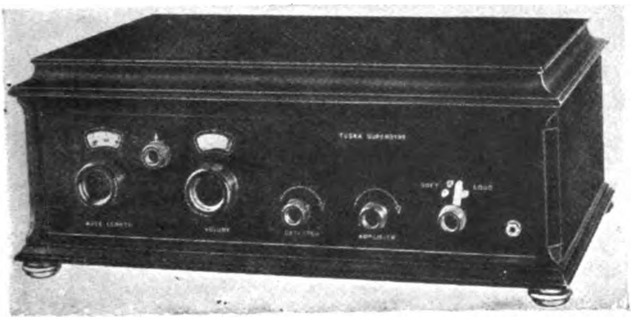
Detector "B" Voltage; 45 volts

Wavelength Range; 250 to 600 meters

Number of Tuning Controls; two

"A" Battery Current Consumed; approx. .03 ampere

"B" Battery Current Consumed; .180 amperes per cell



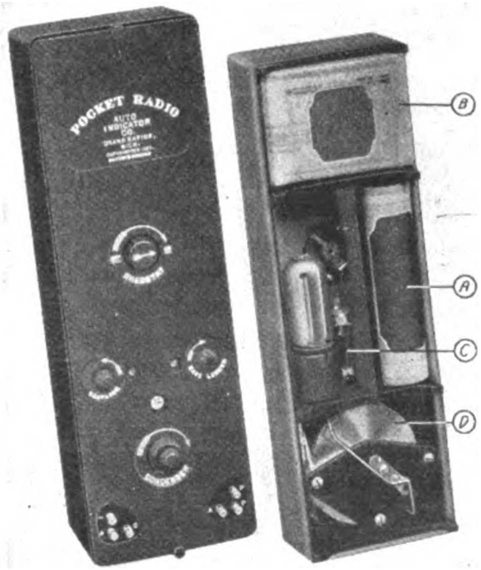
A self-contained four-tube Superdyne with a unique tuning dial. As the knobs are turned the numbers, indicating the setting of the tuning condensers, pass under a hairline. The set is equipped with a loud and soft adjustment.

Tuska Superdyne

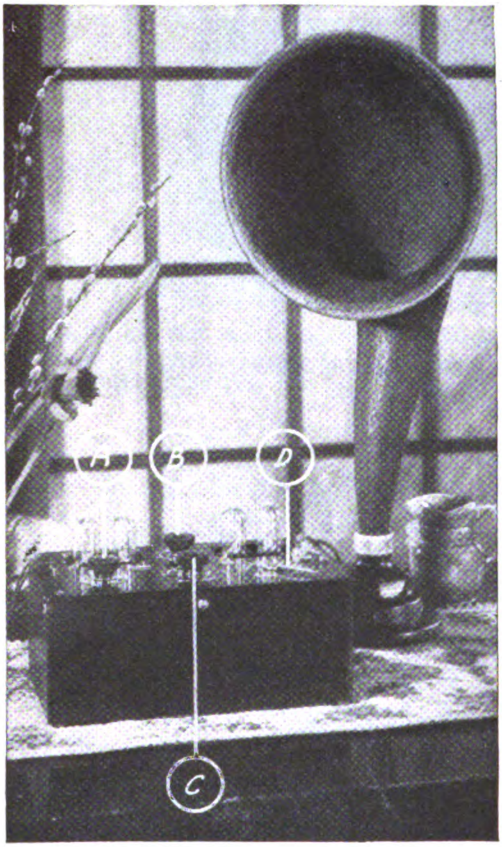
Manufacturer's Name; The C. D. Tuska Co.
Model Number; 305 Superdyne
Number of Tubes; four
Type of Tuning; 1 RF with regenerator
Type of Detector; vacuum tube
Range on Phones; 3,000 miles
Range on Loudspeaker; 3,500 miles
Cost Complete; $85.00
Antenna Recommended: outdoor
Kind of Tubes for R. F.; UV-201-a.
Detector Tube; UV-200
Audio Tubes; UV-201-a
Type of "A" Battery; 6-volt storage
Type of "B" Battery; any standard
Detector "B" Voltage; any standard
Wavelength Range; broadcast range
Number of Tuning Controls; three
"A" Battery Current Used; 1½ amperes
"B" Battery Current Used; 7 milliamperes

Auto Indicator Pocket Receiver

Manufacturer's Name; Auto Indicator Co.
Model; Standard "B" Model Pocket Radio
Number of Tubes; one
Type of Tuning; rheostat and condenser
Type of Detector; non-regenerative
Range on Phones; 1,000 miles
Range on Loudspeaker; not specified
Cost Complete; $32.50
Antenna Recommended; 75 to 100 feet No. 14 copper wire
Kind of Tubes for R. F.; none
Detector Tube; UV-199 or C-299
Audio Tubes; UV-199 or C-299
Type of "A" Battery; dry cell
Type of "B" Battery; dry cell
Detector "B" Voltage; 22½ volts
Wavelength Range; 200 to 700 meters
Number of Tuning Controls; three
"A" Battery Current Used; 06. ampere
"B' Battery Current Used; less than .5 milliampere



A single-tube portable receiver fully equipped with batteries.



A is the regenerative control, B and C are the rheostats, and D is the tuning control.

The Radiola III-A

Manufacturer's Name; Radio Corporation of America

Model; Radiola III-A

Number of Tubes; four

Type of Tuning; *See below

Type of Detector; WD-11 Radiotron, regenerative

Range on Phones; none specified

Range on Loudspeaker; none specified

Cost Complete; $90.00

Antenna Recommended; outdoor, 50 to 150 feet

Kind of Tubes for R. F.; none

Detector Tube; one WD-11 Radiotron.

Audio Tubes; one WD-11 for 1st stage A. F., and two WD-11 for 2nd push-pull stage A. F.

Type of "A" Battery; 4 to 6 dry-cells in parallel, 1.5 volts

Type of "B" Battery; 90-volt dry-cells

Type of "C" Battery; 45-volt dry-cells

Detector "B" Voltage; 20 to 45 volts

Wavelength Range; 195 to 640 meters

Number of Tuning Controls; one

"A" Battery Current Used; 1 ampere

"B" Battery Current Used; no load = 6 milliamperes; full load = 7 milliamperes.

Federal Receiver No. 141

Manufacturer's Name; Federal Telephone Mfg. Corp.

Model Number; type 141

Number of Tubes; five

Type of Tuning; variable capacity

Type of Detector; hard or soft tube

Range on Phones; none specified

Range on Loudspeaker; none specified

Cost; $150.00 (not complete)

Antenna Recommended; not less than 200 mmf. nor more than 2,000 mmf. measured at 600 meters

Kind of Tubes for R. F.; hard tube

Detector Tube; hard or soft tube

Audio Tubes; hard tubes

Type of "A" Battery; 6 volts

Type of "B" Battery; 90 volts

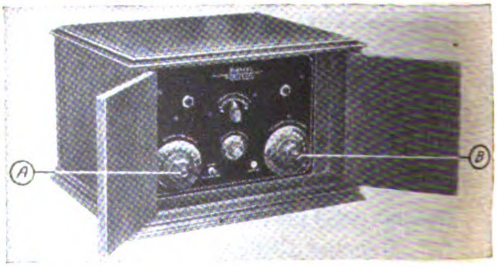
Detector "B" Voltage; 20 volts

Wavelength Range; 200 to 600 meters

Number of Tuning Controls; two

"A" Battery Current Used; 1.25 amperes

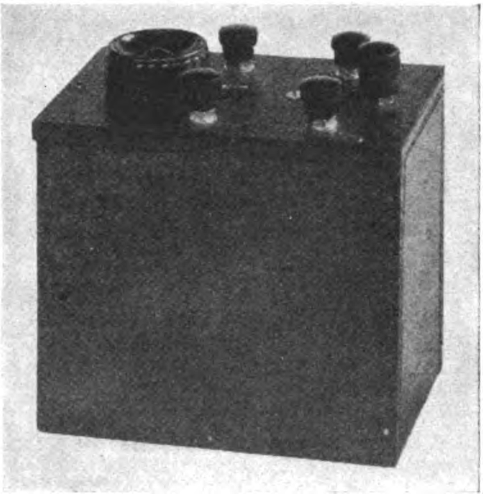
"B" Battery Current Used; 10 to 15 milliamperes



In this receiver, antenna tuning is accomplished with dial A and secondary tuning with dial B, making a simple adjustment

Special Crystal Set

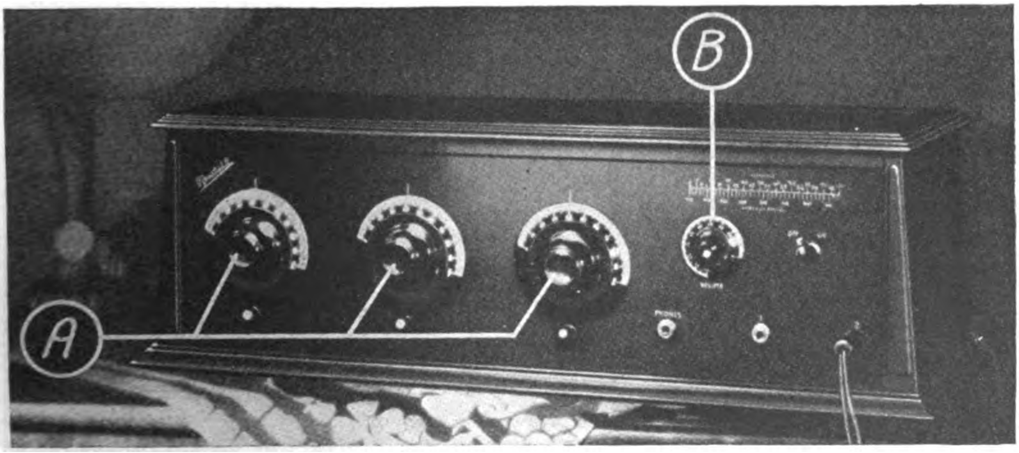
Manufacturer's Name; The A. H. Miller Radio Co.
Number of Tubes; none
Type of Tuning; capacity
Type of Detector; crystal detector
Range on Phones; fifteen to twenty-five miles
Cost Complete; $1.79
Antenna Recommended; 100 feet
Wavelength Range; 200 to 600 meters
Number of Tuning Controls; one



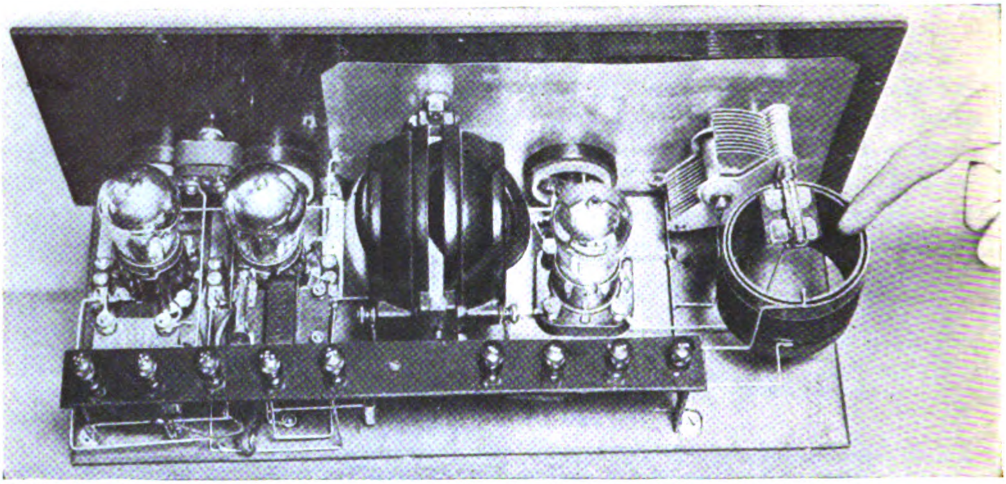
A simple crystal set that can be attached to a temporary antenna and ground in a few moments.

Pfanstiehl Overtone Receiver

Manufacturer's Name; Pfanstiehl Radio Co.
Model Number or Name; Pfanstiehl Overtone
Number of Tubes; five
Type of Tuning; tuned radio frequency (Pfanstiehl non-oscillating system)
Type of Detector; 201-a
Range on Phones; 3,000-5,000 miles
Range on Loudspeaker; 2,000-3,000 miles
Cost Complete; $140.00; plus equipment, $225.00 approximately
Antenna Recommended; outdoor (or indoor wire beneath moulding)
Kind of Tubes for R. F.; 201-a
Detector Tube; 201-a
Audio Tubes; 201-a
Type of "A" Battery; any
Type of "B" Battery; any
Detector "B" Voltage; 22½ volts
Wavelength Range; 200-575 meters
Number of Tuning Controls; three
"A" Battery Current Used; 1.25 amperes
"B" Battery Current Used; 10 to 15 milliamperes



A five-tube tuned-radio-frequency receiver that is exceptionally easy to operate. The three tuning dials, A, are set at approximately the same values in tuning and the volume control, B, is adjusted for the desired strength of signals.



Kadel & Herbert

HOW A GRID-LEAK IS MOUNTED IN A RADIO RECEIVER

A grid-leak and a grid-condenser are shown at the right in the picture near the man's finger. If this grid-leak were not of the proper resistance, it would destroy the selectivity of the set, decrease signal strength and cut down reception range.

Important Trifles in Radio

The Grid-leak

What it is, how it works—and the vital part it plays in your receiving set

By RAYMOND FRANCIS YATES

THE physical insignificance of a device is no indication of its importance. Tiny rivets hold the Woolworth Building together, and safety pins have prevented many disasters.

The little gird-leak, until recently, has been the neglected child of the radio set simply because its appearance does not demand respect. Ask the average fan what it does and he will reply:

"Well, a grid-leak is a—a—resistance which—which—causes a leakage."

Very simple, indeed. A grid-leak is simply a grid-leak.

To become familiar with the function of the grid-leak, let us consider Figure 1.

Here we see an ordinary receiving circuit that has connected to the vacuum tube grid a grid-leak and a grid condenser. Let us assume that the circuit B is tuned to the same wavelength as the antenna circuit A. Oscillations will then be set up in B and this will be connected to the grid with the vacuum tube by way of the condenser. Therefore, the grid will become alternately positive and negative; and each time the grid becomes positive, the electron current will be decreased. Consequently during each wave train the grid will gain a negative charge.

Now, this negative charge is both good and bad. It is good if we control it and bad if we allow it to reach a point that is too high.

We must remember that the little electrons, which are shot off the glowing filament of the tube, are negative in nature and when the grid becomes negative the electrons are forced back to the filament. When negative meets negative repulsion always takes place. Two negative charged bodies always repel each other. Therefore, we must not allow the grid to become too negative if we wish to operate our radio receiver at its most efficient point.

At the end of each wave train this negative charge should leak off through the condenser or through the glass walls of the tube itself. This should happen before the next wave train comes along, and it is to insure such a result that a high resistance is inserted across the grid condenser. This high resistance is called the grid-leak.

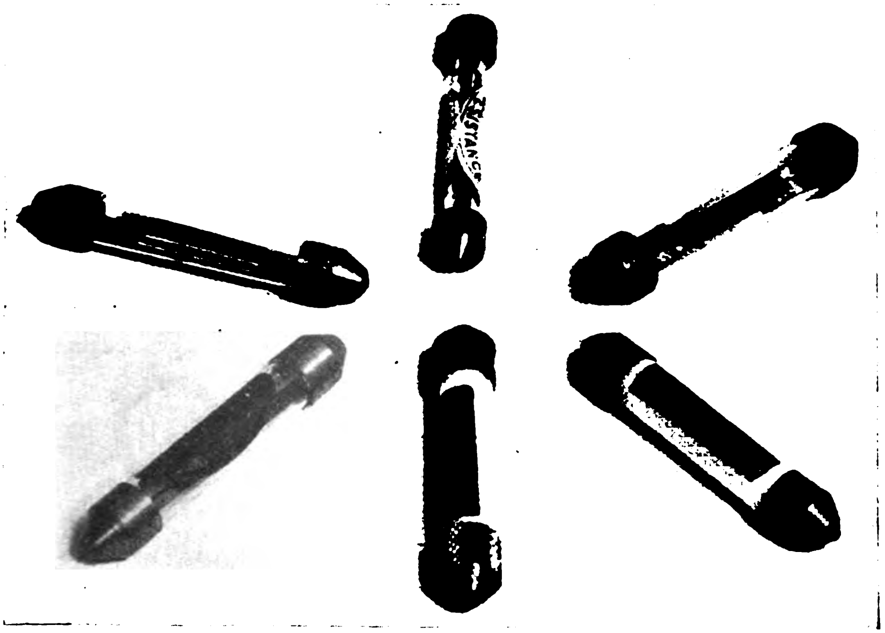
The importance of grid-leaks grows daily. The day of calling a pencil mark on a piece of cardboard a grid-leak is past. Our more sensitive circuits demand a very carefully regulated resistance of constant value and a grid-leak of constant value is a mean thing to make.

Grid-leaks are made by depositing a colloidal carbon ink upon a small strip of paper. So difficult has been the task of making these grid-leaks with an accurate resistance that only one or two manufacturers have the courage to guarantee that their grid-leaks are accurate within 10 percent. The resistance of grid-leaks changes with age, following it appears, as far as physicists know, the same law that holds true for cheese, of which the taste improves with age.

A grid-leak made today will have a resistance three months from now somewhere between ¾ and ½ its original value.

The resistance of grid-leaks is measured in megohms. A megohm is a million ohms. 1/10th of a megohm is then 100,000 ohms and ½ of a megohm is 500,000 ohms. The one megohm type is most used, but I do not mention this as a recommendation.

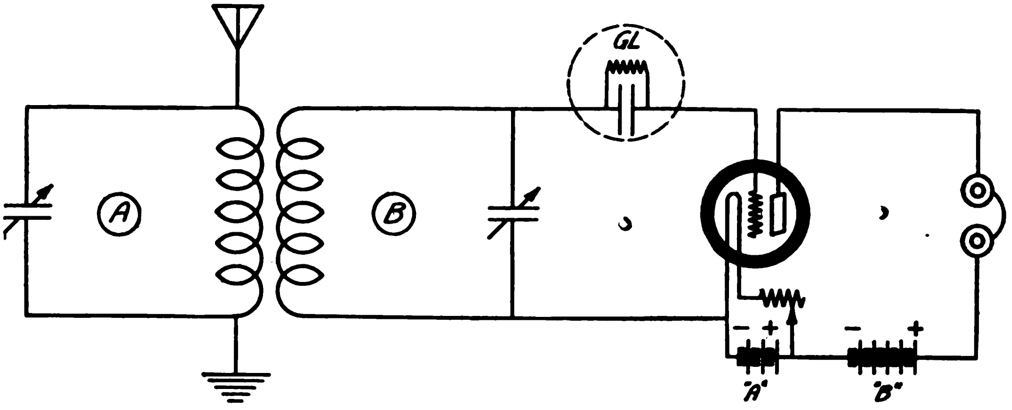
Too many fans choose their grid-leaks



From a photograph made for POPULAR RADIO

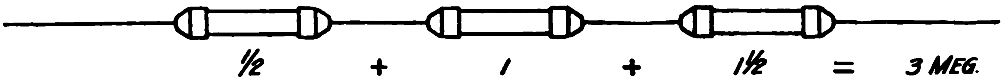
HOW GRID-LEAKS ARE CONSTRUCTED

Grid-leaks are usually made of a strip of insulating material that has been impregnated with some substance containing a carbon or graphite base and hermetically sealed in a glass tube. This construction insures a constant value of resistance that, under other conditions, would be subject to change by atmospheric effects.



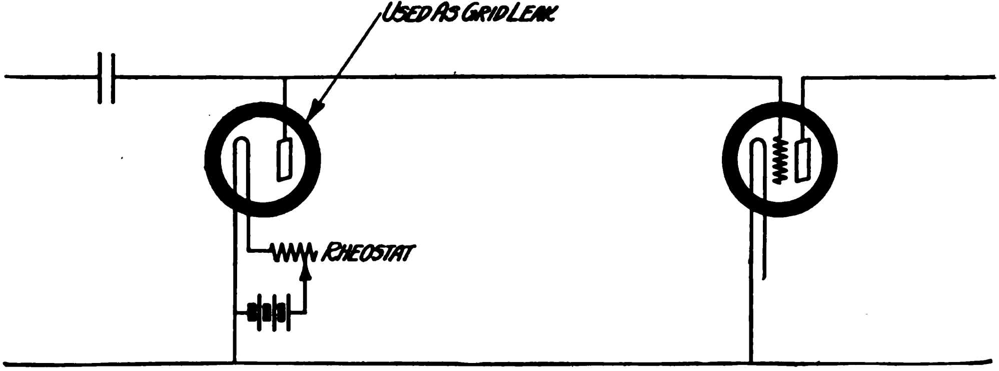
HOW GRID-LEAKS ARE USED IN A RADIO RECEIVING CIRCUIT

Figure 1: *This conventional receiver hook-up shows one of the connections for the grid-leak which acts as a throttle upon the flow of electrons from the grid of the vacuum tube.*



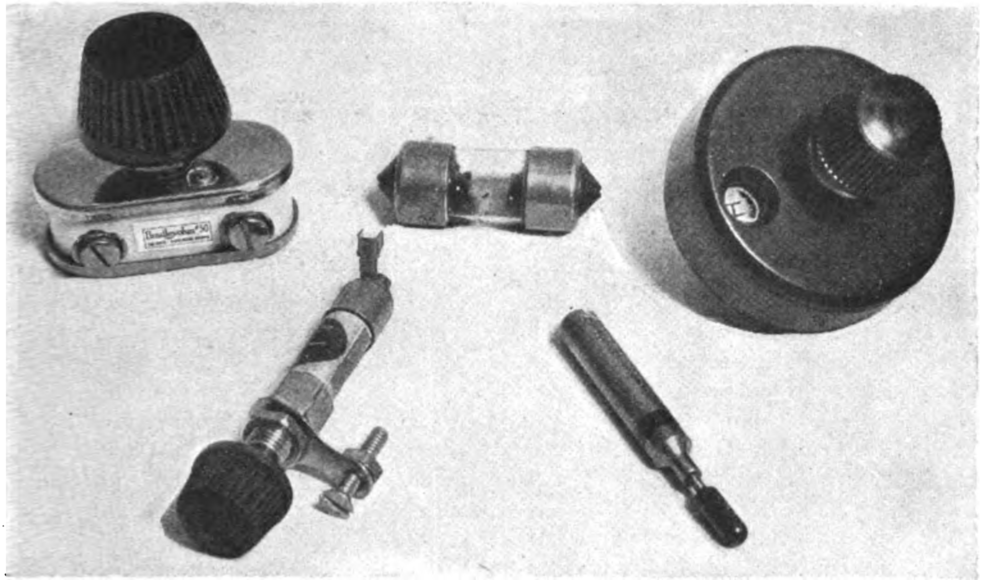
HOW TO FIGURE COMBINED RESISTANCES IN SERIES

Figure 2: *Gird-leaks connected in series as shown in the diagram have a resistance that is equal to the sum of their individual resistances.*



A SUBSTITUTE FOR A GRID-LEAK

Figure 3: *How a two-element tube, preferably one of the old Fleming valves, may be connected in a receiving circuit to perform the function of a variable grid-leak.*



From a photograph made for POPULAR RADIO

VARIABLE GRID-LEAKS OF STANDARD TYPES

Some types of variable grid-leaks are built so that pressure upon a substance varies its conductivity or so that a plunger passes through a loosely-packed, highly resistant substance. In another type a contact slides over a surface that is completely impregnated with a substance like graphite. There is besides a unique grid-leak that contains a high resistant liquid which makes contact on a large or small area of metal terminals as the grid-leak is turned in its contact springs.

on the hit and miss principle. They figure that as long as they have a grid-leak in the circuit or an apology for one, their obligation to this particular part of the outfit is fulfilled, yet, the operating efficiency of many an outfit has been ruined through an unhealthy grid-leak.

No set rule can be given for the use of grid-leaks. Resistances that range all the way from 1/10th to five megohms are used. If we have a pet circuit and want to make sure that we are employing a grid-leak of the proper resistance, there is only one thing to do and that is to cut and try. But one cannot cut and try, if one only has a single grid-leak. If we buy three grid-leaks, one with a resistance of ½ megohm, one of one megohm and one of 1½ megohms, there is a possibility that we may arrange these in a combination of just the necessary resistance. When these resistances are connected in series as illustrated in Figure 2, we add them up to determine the total resistance. Thus the following formula would hold true:

$$R = R1 + R2 + R3$$

When we connect in series, we always add the resistance. Now, if we wish to obtain a lower resistance, we connect the grid-leaks in parallel for which arrangement the following formula holds true:

$$1/R = 1/R1 - L/R2 - 1/R3$$

We see it is possible to juggle our three little grid-leaks around so that we can obtain rather a wide range of resistances.

What is the most perfect form of grid-leak?

There *is* such a thing, yet some of us would probably guess all night before we should hit upon it.

Who would imagine that a perfect grid-leak is a two-element vacuum tube?

When the filament of a two-element tube is cold and no current is passing through it, the resistance of the space between the filament and the plate is infinite. If current is allowed to pass through the filament, the resistance of this space can be changed all the way from infinity to a few thousand ohms. Therefore, a two-element vacuum tube with a battery and rheostat is the most dependable form of variable grid-leak, and the best way of using this variable grid-leak is shown in Figure 3. Of course the average bug will not care to go to this trouble, but for the real radio "crank," I cannot think of anything that will surpass this arrangement for bringing results.

Who would think that a grid-leak would cause circuit noises? But a poor grid-leak will do exactly that. Grid-leaks, aside from being non-inductive and non-capacitative should also be non-microphonic. When tiny carbon particles are brought together they are bound to be microphonic unless they are properly treated. The least movement of these particles due to mechanical disturbance or to temperature effects will alter the resistance of the grid-leak and we will get a registration in the phones. For this reason grid-leaks must be made of the very best materials and thoroughly protected from moisture and other disturbing effects. If we build our own pencil-line grid-leaks, it will be wise to soak them in paraffine after the connections are made.

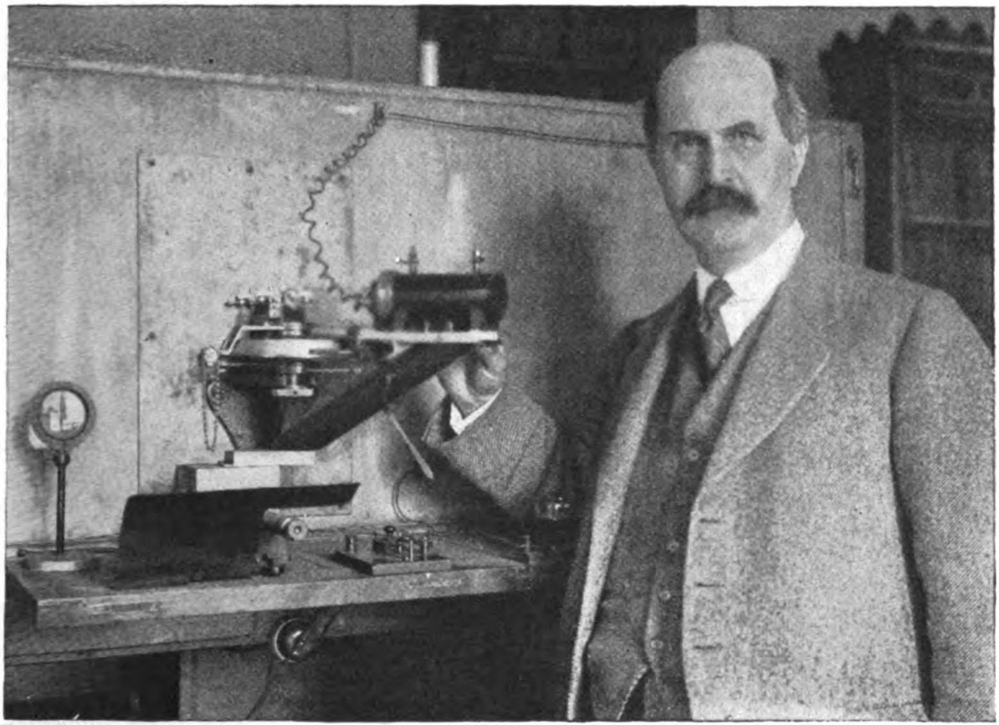
Right here it is well to give a word of warning about the connections. Small clamps of copper are best to use, since much of the trouble in grid-leaks results from poor contact.

This is an appreciation of the lowly grid-leak. Let us remember that it is quite an important thing after all which demands the respect of the set owner just as much as its more aristocratic brothers and sisters, the condensers, coils, vacuum tubes and headphones.

Pacific & Atlantic

RADIO BROADCASTER USES PLANE TO KEEP APPOINTMENT

Art Gillham, known to radio fans as the "Whispering Pianist," has been working on such a crowded schedule while touring the West that he found it necessary to use an airplane in his jumps. A portable organ and a microphone were sent to the air field at San Francisco, where he did his broadcasting with the plane waiting to carry him to his next stop.



Hoppé, London

THE AUTHOR IN HIS LABORATORY

The atom plays such a vital part in the drama of radio that POPULAR RADIO *has turned to one of the world's foremost authorities for a series of short popular articles on this subject that every radio fan should know about. Sir William Bragg of England is the Fullerian Professor of Chemistry at the Royal Institution and Director of the Davy-Faraday Research Laboratory.*

The ATOM

ARTICLE NO. 1

Scientists tell us that the entire universe is made up of only ninety different kinds of atoms. Tremendous power is believed to lurk within these minute and constantly moving particles. To solve the age-old mysteries that lurk within them and to harness their energy has now become one of science's greatest problems.

By SIR WILLIAM BRAGG, K.B.E., D.Sc., F.R.S., M.R.I.

TWO thousand years ago, Lucretius, the famous Latin poet, wrote his treatise, "*De Rerum Natura*"—"Concerning the nature of things." He maintained the view that earth and water and air and all things were composed of innumerable small bodies or corpuscles, each too small to see, and all in rapid motion. He tried to show that these suppositions were enough to explain the properties of material things.

There was a rival set of views, according to which there would be no evidence of structure, however closely things were looked into.

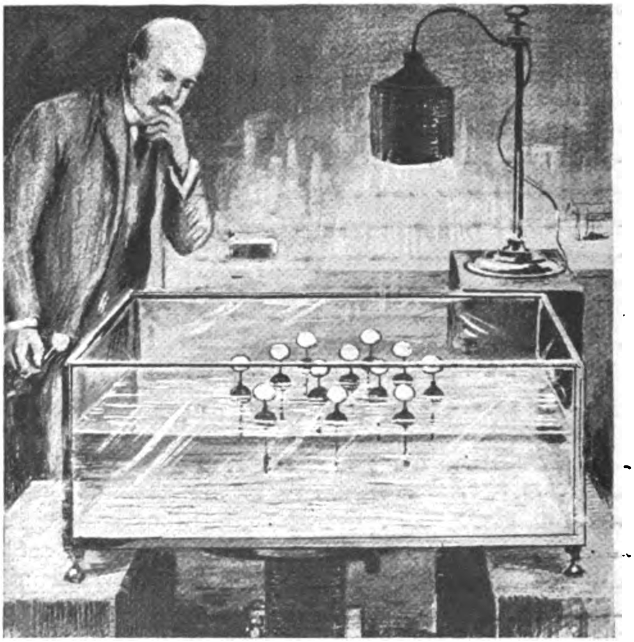
If, for example, the water in a bowl were divided into drops, and each of these into smaller drops, and so on *ad* *infinitum,* the minutest portion would still have all the properties of water. On the view of Lucretius, if sub-division were carried out sufficiently, one would come at last to the individual corpuscles or atoms: the word atom being taken to have its original meaning—that which cannot be cut.

There is a mighty difference between the two views. On the one, there is nothing to be gained by looking into the structure of substances more closely, for, however far we go, we come to nothing new. On the other view, the nature of things as we know them must depend on the properties of the atoms of which they are made. It becomes a matter of the highest importance and the greatest interest to find out, if we can, what the atoms are like.

Fortunately, at least for those who love to inquire into the ways of Nature, the view maintained by Lucretius turns out to be the closer to the truth.

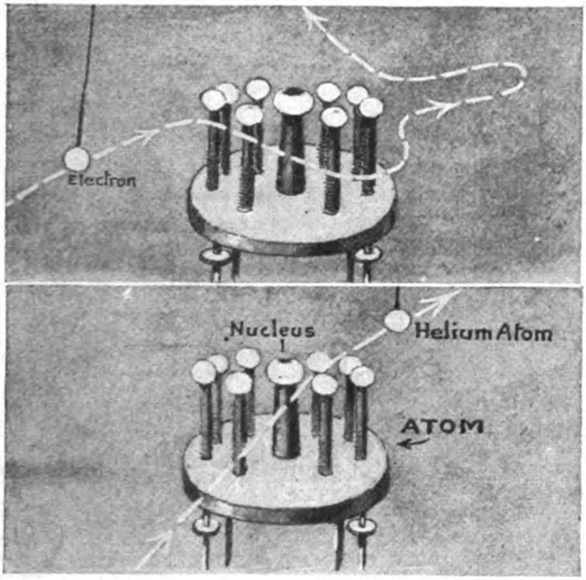
Lucretius had, however, no conception of the modern form of the atomic theory, the form which has made possible the tremendous advance of the last century in chemistry and physics. He did not realize that there are atoms of a limited number of sorts in the world, and that all the atoms of one sort are alike. That idea is comparatively new; and it makes the whole matter much simpler. We have to examine the properties of a few sorts of atoms only, not those of an infinite number of different individuals.

There are some ninety sorts of atoms, of which the whole world is made and all that is in it, and the universe, as far as we know it. Some kinds of atoms are used freely; others very sparingly. The marvel is that the atoms are not only the elements of construction, but also everything required for the building. They are not only the bricks; they are also the cement and the tools and the plan, for no other material is found be-



A HINT AT ATOMIC ACTION

FIGURE 1: *Ping-pong balls, when mounted on floating magnets which are controlled by a sunken master magnet, will tend to arrange themselves in a definite pattern. Science believes that atoms in a molecule do something of the same sort.*



HOW AN ELECTRON IS REPELLED BY AN ATOM

Figure 2: *A slowly moving electron fails utterly in its effort to penetrate an atom; the dotted line in the upper drawing shows the nature of its erratic course. A helium atom, flying into another atom, and moving too close to the nucleus, is sharply deflected from a direct line as is indicated in the lower figure. Only the great speed at which an electron moves makes it possible for it ever to force its way into an atom.*

side them. We are, of course, considering material things only.

We therefore are bound to ask what the atoms are like, and what inner structure they have to account for the fact that they may be combined in such infinite variety. We have a better understanding of the atom than Lucretius; our wonder is correspondingly deeper.

In the last quarter of a century or so, two new agencies have helped us to see more closely into the constitutions of the atom itself: they are our studies of radio-activity and of X rays.

We may say that there were three broad principles, each well established, which were the basis of scientific advance before the last period set in.

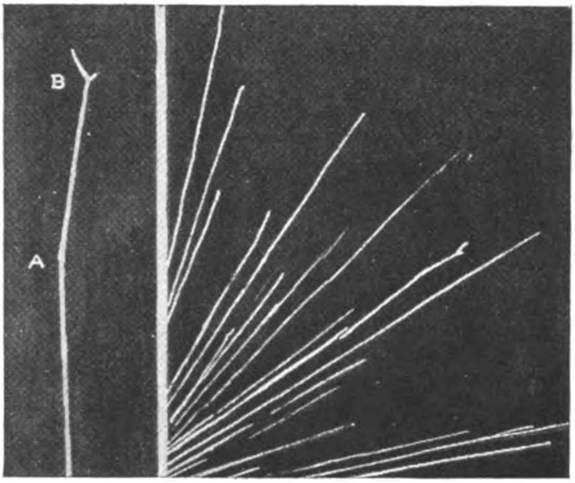
The first of these was the grouping of atoms into different kinds, as already explained.

The second recognized the existence of forces drawing the atoms together, as exemplified in any solid or liquid, and even in gases, though in that case their detection is difficult.

The third asserted that all atoms were in constant motion, even when they were the constituents of a body which seemed perfectly quiet, such as a table, or a piece of paper.

This idea is fundamental to all modern science, pure and applied; it is involved both in the most abstruse theoretical researches and in every industrial process. Although the recognition of heat as the consequence and equivalent of motion was often obscured by other theories, yet there have always been men who held sound views on the point. One of these was Hooke, a famous scientist of the seventeenth century.

> "Heat," he says, "is nothing else but a very brisk and vehement agitation of the parts of a body . . . whereby the parts of a body are made so loose that they become fluid. . . . Let us suppose a dish of sand set upon some body that is very much agitated . . . on a very stiff drumhead, which is vehemently or very nimbly beaten with the drumsticks. By this means the sand in the dish . . . becomes a perfect



EXPLODING RADIUM SHOOTS OUT HELIUM

FIGURE 3: *After living a perfectly normal life, radium suddenly explodes and sends out a helium atom—flying like a shot from a gun at the surprising speed of about 100,000 miles a second. The diagram shows, at A and B the two points of deflection as the helium drives through other atoms.*

> fluid; and ye can no sooner make a hole in it with your finger but it is immediately filled up again and the upper surface of it levell'd. Nor can you bury a light body, as a piece of cork under it, but it presently emerges or swims as 'twere on the top: nor can you lay a heavier on the top of it, as a piece of lead, but it is immediately buried in sand and (as 'twere) sinks to the bottom."

The motions of the atoms act contrarivise to their mutual attractions; the former tend to keep them apart, the latter to draw them together. When the former are supreme, the substance is a gas; when the latter, a solid. The liquid state is intermediate, as will be explained later.

We now come to the contributions which we owe to radioactivity.

In order to account for the fact that a solid body very strongly resists compression, we have been accustomed to suppose that each atom occupies a certain volume, and that there is a considerable difference between the volumes of the different kinds. For instance, potassium is lighter than water, while diamond is more than three times as heavy as the latter. We know, too, that the potassium atom is more than three times as heavy as the carbon atom which is the sole constituent of the diamond. The former must, therefore, be much more bulky than the latter. If we suppose, for want of better knowledge, that the atom is spherical, we can calculate the relative sizes of the two spheres.

Each atom has, so to speak, a domain into which all our efforts at compression cannot force another atom to enter. Radium shows us, nevertheless, that, under circumstances beyond our power to bring about by the greatest exertion of pressure, one atom can not only penetrate another, but can actually pass right through without permanent injury to either. For a moment two atoms occupy the same space.

A radium atom is like any other, all its life. But its life ends; and the death involves a cataclysm of a most surprising nature. For one or two thousand years the radium atom goes about its business in a normal way; and then explodes suddenly, dividing itself into two portions, one large and one small. The latter goes off like the shot from a gun, and its velocity is about 100,000 miles a second; so that, if unchecked, it would reach the moon in two seconds and a half. Nevertheless, it is brought to rest in two or three inches in the open air; and in a much shorter distance in any solid material. Its arrest is due to loss of energy in driving *through* the hundreds of thousands of atoms which it meets. The projectile is actually an atom of helium, the lightest atom except hydrogen.

If one atom goes straight through another, when the speed is so great, and cannot be forced into it by more ordinary means, we are led to picture the atom as a domain occupied by some sort of inhabitants who are able to keep out another set when they are not moving too fast. A number of soldiers might occupy a certain piece of territory, and an approaching army might under normal circumstances be unable to enter. But if the second army came at the rate of, say, a hundred miles a second, the first army might not even know their territory had been penetrated; unless, of course, two soldiers happened to collide!

Or we may illustrate the point by means of the models shown in Figure 2.

A number of magnets stand on end in a circle, each mounted on a spring. A magnet suspended at the end of a long card is made to approach the circle gently. If the polarities of the magnets are rightly arranged, the swinging magnet will recoil and try vainly, at various points, to enter in. If, however, it is drawn back far enough, so that it comes at the circle with a rush, it will go through. It will set the standing magnets quivering on their springs, just as, in fact, the parts of an atom are known to be set in motion in the analogous case.

It is found that we must further elaborate the idea of the atom's structure by supposing that the mass of the atom is centered in a nucleus *positively electrified.* Around this are arranged a number of "electrons," *negatively electrified and all alike.*

We have now made it resemble a miniature solar system.

The upper half of Figure 2 shows what happens if an electron—not moving too fast—encounters an atom. The lower half shows a helium atom, a nucleus only, because in its excessive speed it actually loses its two satellite electrons going through an atom it has met, and going so near the nucleus that it is sharply deflected; as at *A* and *B* in Figure 3. At *B* can even be seen a minute track like a spur where the atom that has been driven into too directly has been pushed off to one side.

The electrons of an atom are arranged in some order about the nucleus, and when we try to picture to ourselves how this may be we sometimes make use of the model shown in Figure 1. Here a number of floating magnets are arranged so as to repel each other, while they are all drawn towards a center provided by a strong magnet underneath the tank in which they float. Obviously a regularity of arrangement will ensue, but the model claims no exactness of analogy. It is pretty to put the magnets in the corner of the tank, and watch them move into their places in a stately fashion.

The RADIO GROUCH

JUDGING from the amount of public squeaking there is on the air, some of the stations ought to lay in a supply of broadcaster oil.

❦

I DON'T mind having my morals improved within reason, but sometimes I think there are too many transmissionaries to the heathen.

❦

THE radio, I hear, is now permanently established as a feature of political campaigns, but I notice that there are still a lot of politicians who stick to the good old party wire.

—HOWARD BRUBAKER

WHAT READERS ASK

CONDUCTED BY LAURENCE M. COCKADAY

In *justice to our regular subscribers a nominal fee of fifty cents per question is charged to non-subscribers to cover the cost of this service, and this sum must be inclosed with the letter of inquiry. Subscribers' inquiries should be limited to one question or one subject.*

How to Add Two Stages of Audio-frequency Amplification to a Crystal Tuner

QUESTION: Please show me how to add two stages of amplification to a crystal set that consists of a variocoupler with a series variable condenser in the antenna circuit and a shunted variable condenser connected across the secondary coil. I am interested only in local programs for clear reception and I want to use this on a loudspeaker or occasionally on the phone.

R. J. CARROLL

ANSWER: The circuit that we have prepared for you is shown in Figure 1. The parts that you will need in building this simple set are shown in the following list:

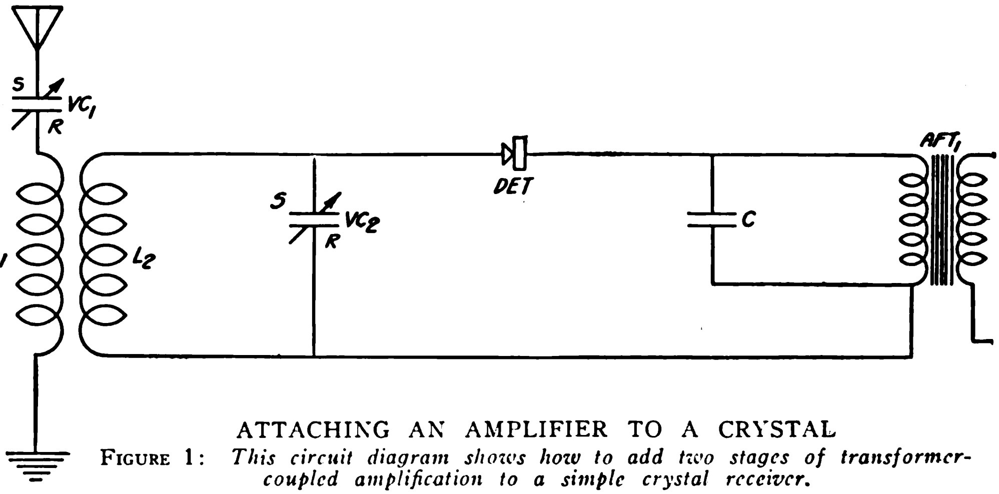
L1 and L2—primary and secondary coils of variocoupler;
VC1 and VC2—variable condensers, .0005 mfd.;
DET—crystal detector;
C—mica fixed condenser, .0005 mfd.;
AFT1 and AFT2—audio-frequency amplifying transformers;
R1 and R2—filament rheostats, 5 ohms;
TEL—telephones or loudspeaker.

You will need two WD-12 or C-12 tubes and sockets for this receiver. If these are used the "A" battery should consist of three 1½-volt dry-cell batteries connected in parallel.

This receiver should give you very clear reception on local signals.

Straight Panels or Slanting Panels for Radio Receivers?

QUESTION: Which do you think is the most convenient type of panel to use on



ATTACHING AN AMPLIFIER TO A CRYSTAL

FIGURE 1: *This circuit diagram shows how to add two stages of transformer-coupled amplification to a simple crystal receiver.*

a radio receiving set—the straight vertical type or the slanting panel that faces the eye of the operator?

S. SIEHMS

ANSWER: We prefer the sloping panel from the standpoint of ease of operation of a radio receiving set. The panel should be at right angles to the line of vision of the operator when he sits at a comfortable arms-length from the radio receiving set. Using a radio table of standard height and sitting on a chair (also of standard height) with the arms bent in a comfortable position and the hands on the dials, it will be found that a panel with a slope backward of 25 degrees will just meet this condition, giving the operator a clear view of the dials and the dial settings without straining his arms, his neck or his eyesight.

Connection Wire to Use

QUESTION: What kind of bus wire do you believe to be more suitable for wiring up a home-built radio receiving set?

T. RAMOS

ANSWER: Use a round bus wire of about No. 12 gauge. This can be bent in the desired shape necessary when connecting the various instruments with the least effort and it makes a good looking job. When wires cross a small piece of spaghetti tubing may be used to act as an insulator against possible short circuits, but on the whole we would advise that the tubing is used extremely sparingly.

The "Town and Country" Receiver as a Permanent Set-up

QUESTION: Will Mr. Taylor's "Town and Country" portable receiver (described in POPULAR RADIO for May, 1925) be suitable for operation in my apartment house (which is of steel construction) for all-year-round use? I have studied the article describing this set and it appeals to me very much as I am unable to use an outdoor antenna. I do not need a portable set, however, and I am wondering if this receiver will be satisfactory for all-year-round use in such a location.

D. TUSKA

ANSWER: This receiver should give you fine results in this location where you cannot put up an outdoor antenna. We recommend its use for any purpose whether in town or in the country.

The Size of Rheostats for the WD-12 Tube

QUESTION: What is the proper size of rheostat to use with the WD-12 type of tube operating on an ordinary radio dry-cell battery?

R. TIETJEN

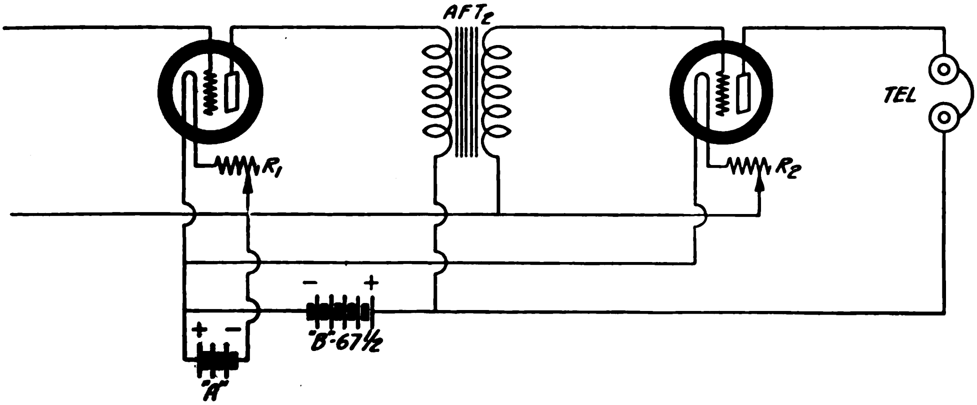
ANSWER: Use a rheostat of 5 or 6 ohms resistance.

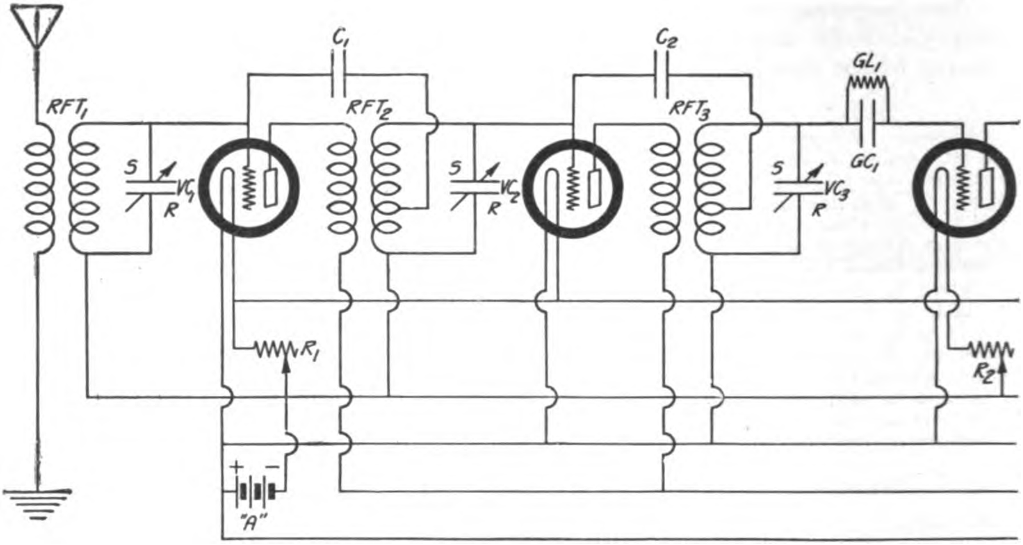
Radio-frequency Added to the Regenerative Receiver

QUESTION: Is it possible to add a stage of radio-frequency to a regenerative receiver in order to cut out radiation?

F. HAXTON

ANSWER: Yes, this is a practical scheme. If the radio-frequency tube contains the familiar neutralization method of eliminating feedback, the question of radiation is solved.





A NEUTRODYNE WITH ONE STAGE OF TRANSFORMER-COUPLED AND ONE STAGE OF IMPEDANCE-COUPLED AMPLIFICATION

FIGURE 2: *This circuit shows the electrical connections for a standard neutrodyne receiver employing two stages of neutralized radio-frequency amplification, vacuum tube detector, one stage of transformer-coupled audio-frequency amplification and a single stage of impedance-coupled amplification.*

An Efficient Neutrodyne Receiver

QUESTION: Will you kindly give me a wiring diagram for a neutrodyne receiver that employs two stages of radio-frequency, vacuum tube detector and one-stage of transformer-coupled audio-frequency amplification and one-stage of impedance coupled amplification? I would like to use the standard UV-201-a vacuum tube throughout except that I want to use a UV-200 tube for the detector.

JOHN TUTT

ANSWER: In figure 2 you will find a circuit diagram that shows the connections for a receiver of the type you require. The parts that you will need for building this set are the following:

RFT1, RFT2 and RFT3—standard neutrodyne radio-frequency couplers;
VC1, VC2 and VC3—variable condensers, modified straightline wavelength, .00035 mfd.;
C1 and C2—neutrodon compensating condensers;
GL1—variable grid-leak;
GL2—fixed grid-leak, ¼ megohm;
GC1—mica fixed condenser, .00025 mfd.;
GC2—mica fixed condenser, .006 mfd.;
C3—mica fixed condenser, .0005 mfd.;
R1—filament rheostat, 6 ohms;
R2—filament rheostat, 6 ohms;
AFT1 and AFT2—audio-frequency amplifying transformers;
J1 and J2—double-circuit jacks;
J3—single-circuit jack.

The first two and the last two tubes should be either C-301-a tubes or UV-201-a tubes, or any of the standard makes of "hard" vacuum tubes of this general type. The third tube (the detector tube) should be a UV-200 tube or a C-300 tube. All the tuning is done with the three condensers, VC1, VC2 and VC3, the two small variable condensers, C1 and C2 being used to neutralize the circuit.

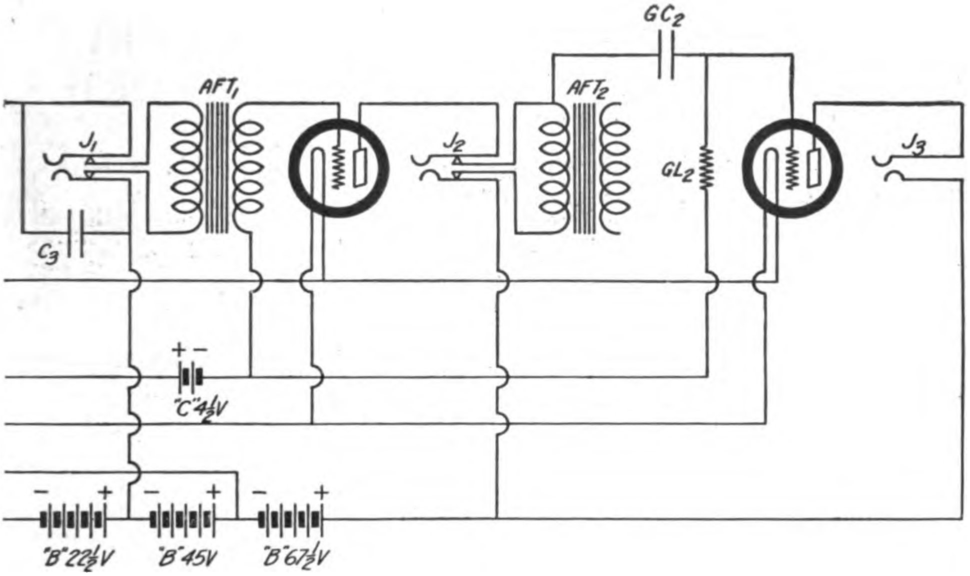
The transformer, AFT2 is used only as an impedance, the primary being left open and the secondary terminals being connected to the two inner terminals of the jack, J2.

Condensers for Filter Circuits in "B" Eliminators

QUESTION: Do you recommend the use of the Dubilier bypass condenser in the filter circuits of "B" eliminators?

R. NORDSTRUM

ANSWER: We do not recommend the use of this instrument. It may operate for a short time but it will eventually break down and cause a short circuit of the apparatus. This does not mean that this instrument is an inferior one. The Dubilier Condenser & Radio Corporation advise against the use of this apparatus for such purposes.



Binding Posts on the Panel or at the Rear of the Set

QUESTION: Which do you deem the advisable method for constructing a receiver—to incorporate the binding posts directly on the front panel or to place them on a strip at the rear of the radio set?

JERRY LAUTERBACH

ANSWER: We recommend that you use a small panel at the rear of the set for the antenna, ground, and battery connections. This keeps any stray voltages away from the operator's hands and also helps to eliminate body capacity from the antenna circuit.

A Fuse for the "A" Battery Circuit

QUESTION: Recently my storage battery leads happened to touch each other, with resultant violent sparking and heating of the leads. How can I prevent a recurrence of this trouble?

A. FRAZIER

ANSWER: Get a fuse block with a single six ampere fuse such as is used for electric light wiring. Put it in series in one of the "A" battery leads by disconnecting one wire from the storage battery and changing it to one terminal of the fuse block; then connect the other terminal of the fuse block back to the vacant binding post of the storage battery. Now, the fuse will blow in case of a short circuit.

The Hot Wire Ammeter

QUESTION: What kind of inexpensive ammeter can be used for measuring either alternating or direct current? I would like to measure the current when my alternating current charger is charging my storage battery, and also the direct current when vacuum tubes are lighted from the storage battery.

F. HUTCHINSON

ANSWER: The small hot wire type of ammeter should suit your purpose. This style meter measures the current indirectly as the current serves only to heat a thin wire or strip in the meter, just as it would heat the wires in a toaster or other electric appliance. The expansion of the hot wire due to heating is transferred to the needle of the meter by a lever system and thus the amount of heating (and the current causing it) are measured.

Useful Charts for Amateurs

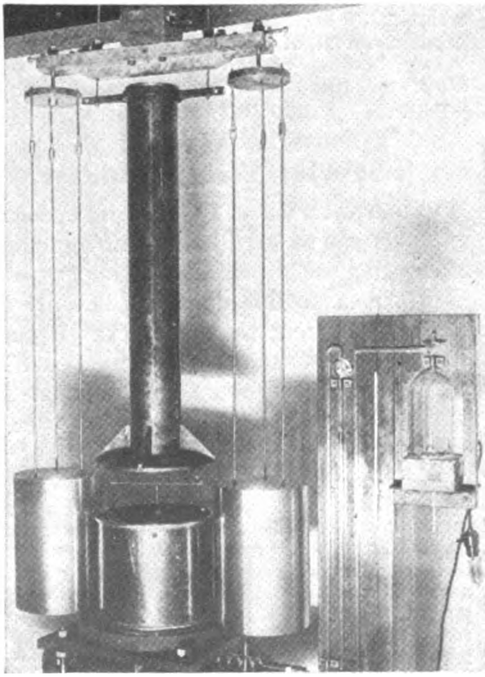
Nine information and computation tables for the guidance of experimenters who design or build receiving sets—in POPULAR RADIO *for September.*

IN THE WORLD'S LABORATORIES

Conducted by Dr. E. E. Free

New Theories of Ether Waves

Readers of this department are already familiar with the idea that ether waves may not be waves at all but tiny particles like bullets of light. These supposed particles are called *quanta;* the theory which imagines them to exist is called the quantum theory. If they are real at all they must be extremely tiny. Electrons would be millions of times larger.*



Pacific & Atlantic

WHAT IS GRAVITATION?

New theories of ether waves have prompted renewed attack on the mysterious cause of gravitation. The Bureau of Standards is using this apparatus to weigh the earth.

There are many facts which favor this quantum theory. One, for example, is what physicists call the photo-electric effect. Certain metals, notably the metal potassium, have the property of giving off electrons when light falls on them. This was the basis of the famous "hearing starlight" experiments of General Ferrié and M. Jouaust. A ray of light from the star fell on a small potassium cell. This gave off electrons. The electric charges thus produced were magnified by amplifiers and made audible.

Now when one measures very accurately the speed of the electrons thus given off from potassium (or other metals) under the action of rays of light it is found that this speed is constant for a definite kind of light regardless of how strong the light is. A still more startling experiment can be performed with X rays. If a stream of rapidly moving electrons is directed against a metal plate X rays are given off by the plate. That is how the usual X-ray tubes work. The wavelength of the X rays produced depends upon the speed of the bombarding electrons.

Now let the X rays thus produced fall on another metal plate. Electrons are set free, for the photo-electric effect works with X rays just as it does with the longer waves of visible light. Now comes the surprise. The electrons set free from the illuminated metal plate have the same speed (with certain small and explainable variations) as had the electrons that produced the X rays in the beginning. This is true even when the source of the X rays and the plate on which they fall are far apart, so that the X rays are greatly enfeebled by the distance.

---

*For brief accounts of the quantum theory see "Are Ether Waves Composed of Minute Particles?" in this department of **Popular Radio** for February, 1924, pages 207-209; "Is There a Universe Still Smaller than Electrons?" **Popular Radio** for July, 1924, pages 82-83; "Ether Waves that Move in 'Squirts'," **Popular Radio** for March, 1925, pages 291-292; "Another Theory of Particles Smaller than Electrons," **Popular Radio** for May, 1925, page 483.

The really remarkable character of this result is apparent from a vivid illustration which we owe to Sir William Bragg. Suppose, he says, that a plank falls off a ship in the harbor of New York City and makes a tiny wave in the ocean. Suppose, then, that this wave crosses the ocean, becoming continually feebler by mere spreading of the wave-front, and enters the harbor of Liverpool. And then suppose that a plank floating in the harbor there instantly jumps up to the deck of a ship. That would be truly remarkable. Yet that is exactly what happens in the sequence of moving electron, X ray and emitted photo-electron, as described above.

It has been quite impossible, so far, to explain this result on the basis of the wave theory of ether waves. The wave would be far too feeble, at a distance, to eject an electron with the same energy as was possessed by the electron which started the wave. But on the theory of light bullets, or quanta, this is all quite clear. The energy of the "wave" would be concentrated in single bundles—the quanta. If one of these quanta happened to hit the plank in Liverpool the plank would jump with the same energy that started off the quantum in the beginning.

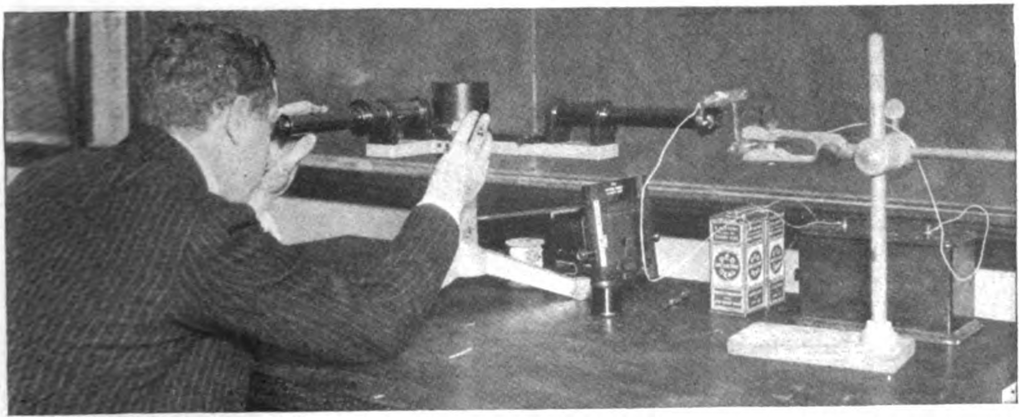
That is part of the case for quanta. It is typical of the other arguments. There are some facts like this, most of them discovered only recently, which can be explained easily enough on the idea of light particles but which will not fit at all into the older idea of ether waves.

On the other hand there are some facts which the wave theory explains well but which the quantum theory will not explain at all. Among these are the facts of what is called interference, facts well known for years in the science of optics and which are finding radio application, nowadays, in modern theories of fading.

At present we are in the position of having two mutually contradictory theories of ether radiation—light, X rays, radio waves and the rest. Each theory fits some facts and refuses to fit others. Yet all the facts, no matter how contradictory, are demonstrably true.[†]

There have been numerous attempts to reconcile these two theories. One of them is due to Dr. Nils Bohr, of atomic fame, and two of his collaborators.[‡] They imagine atoms to be radiating ether impulses all the time. Normally this radiation is imperceptible. Only when the radiation of an atom changes from one kind of radiation to another do we perceive anything; either a light ray or some X rays or a radio wave or some other radiation.

Another suggestion, made originally by no less an authority than Professor Albert Einstein and quoted with approval by Sir Oliver Lodge[§] has been repeated recently by the distinguished English astronomer and mathematician, Dr. J. H. Jeans.[‖] According to this theory the apparent ether wave is unreal and represents merely the places in space at which the flying quanta have a high probability of acting on the atoms or electrons of matter. A third suggestion, made by Sir Joseph Thomson,



Brown Brothers

STUDYING ETHER WAVES IN THE LABORATORY

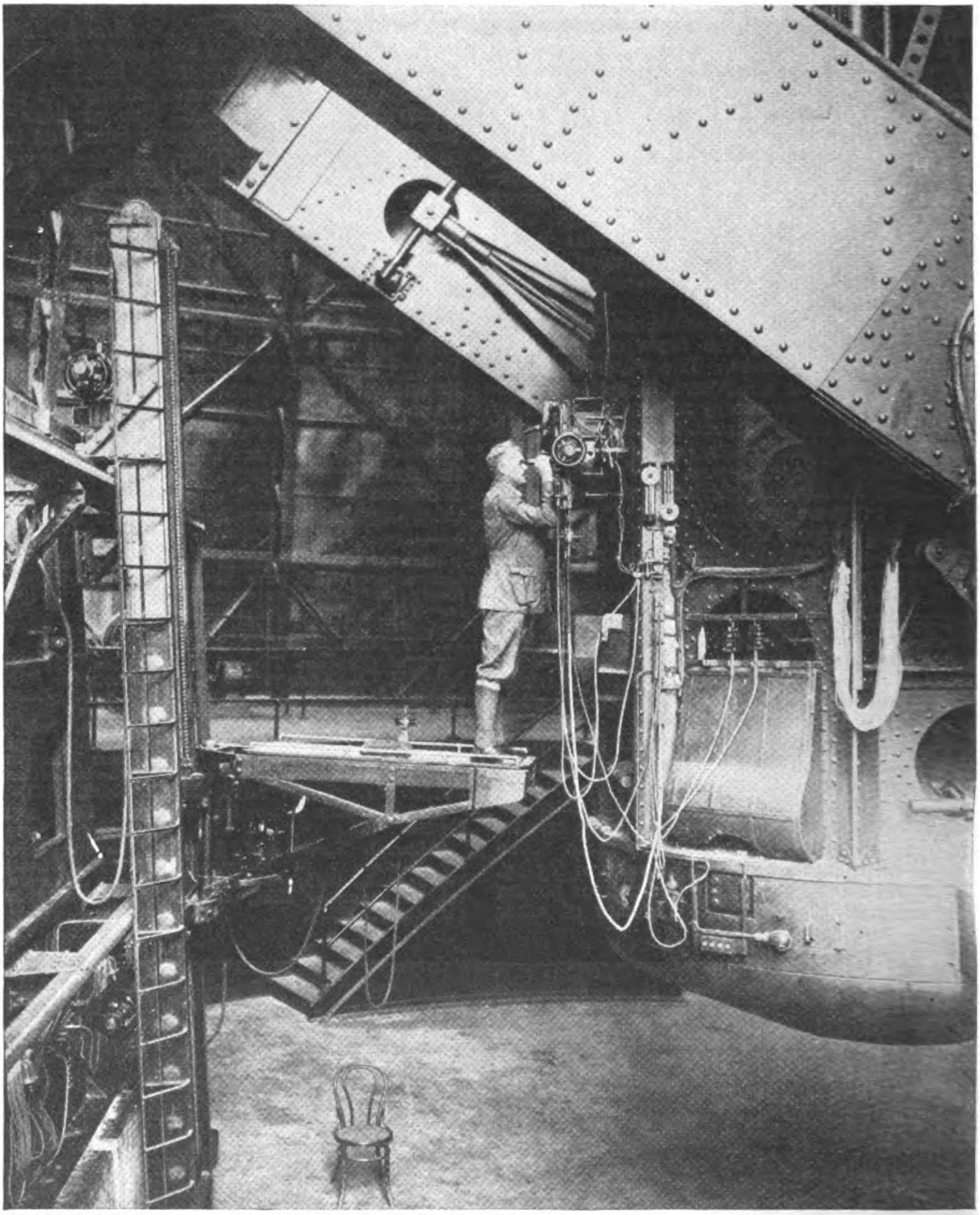
This form of spectroscope is used for visual study of the light rays sent out by electrified atoms in the small glass tube at the right. For more precise work a photographic plate is attached to the instrument, replacing the eye of the observer.

[†] One of the best recent summaries of this conflict between the wave theory and the quantum theory is "Some Contemporary Advances in Physics—VII. Waves and Quanta," by Karl K. Darrow, *Bell System Technical Journal* (New York), vol. 4, pages 280-326 (April, 1925).

[‡] "The Quantum Theory of Radiation," by Nils Bohr, H. A. Kramers and J. C. Slater, *The Philosophical Magazine* (London), vol. 47, pages 785-802 (May, 1924); also published (in German) in *Die Zeitschrift für Physik* (Berlin), vol. 24, heft 2, pages 69-87 (1924). Dr. Slater has recently amplified the theory somewhat in "A Quantum-Theory of Optical Phenomena," *The Physical Review* (Corning, N. Y), vol. 25, pages 395-428 (April, 1925).

[§] See POPULAR RADIO for February, 1924, pages 207-209.

[‖] "Electric Forces and Quanta." Lecture before the Institution of Electrical Engineers, London, February 5, 1925; published in *Nature* (London), vol. 115, number 2888, supplement, pages 361-368 (March 7, 1925).



Mt. Wilson Observatory

LIGHT WAVES FROM MILLIONS OF MILES AWAY

Standing at the focus of the great telescope at Mount Wilson, Cal., Mr. Francis G. Pease is measuring the size of the distant variable star called Mira. This star shrinks and swells in a regular cycle. The measurements are made by interference, one of the phenomena very difficult to explain by the quantum theory.

contemplates the simultaneous emission of *both* ether waves and quantum particles.¶

But more appealing than any of these—at least to the radio engineer—is a suggestion made by Louis, Duke de Broglie, a French nobleman who has been for several years a persistent student of the quantum evidence.*

¶"A suggestion as to the Structure of Light," by Sir J. J. Thomson, *The Philosophical Magazine* (London), vol. 48, pages 737-746 (October, 1924).

*This idea was first suggested to the French

He suggests that radiation may consist of individual, very tiny quanta, inside each of which there is going on some kind of periodic phenomenon characterized by a definite frequency. One might think of it, for example, as being a periodic motion of the electric and magnetic forces inside the tiny quantum.† A simple mechanical analogy would be a spherical ball which alternately shrunk and expanded along its axis, taking alternately the shape of an egg and of an onion.

While we are in the habit of speaking glibly of "waves" in the ether, we really have no evidence that any such things exist. What we do have evidence for is *frequencies;* some kind of phenomenon that recurs at regular intervals. This is especially true in radio; radio-frequencies mean much more to us than radio "waves." The suggestion of the Duke de Broglie gives us these frequencies plus the idea of compact particles or "bullets" of energy.

As yet these new theories have been applied mainly to the facts of light and of X rays. Radio engineers will watch with interest their extension to the lower frequencies.

More Atoms Consent to Be "Stripped"

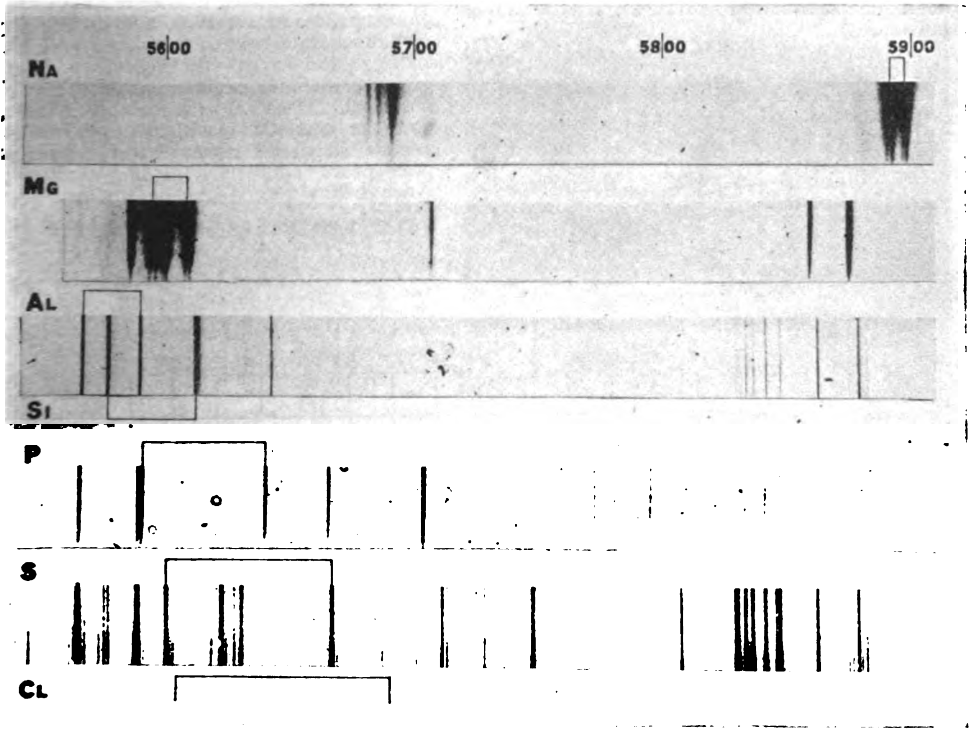
In Popular Radio for August, 1924, Dr. R. A. Millikan, distinguished American physicist and now president of the California Institute of Technology, described the remarkable experiments of himself and Dr. Bowen, in "stripping" off one or more of the electrons from the outer structure of atoms.* All atoms consist, you remember, of a central nucleus around which revolve a greater or lesser number of electrons, much as planets revolve around the sun. By using very hot

---

Academy of Sciences nearly two years ago; see the *Comptes Rendus de la Academie des Sciences* (Paris), vol. 177, pages 507-510 (September 10, 1923) and pages 548-550 (September 24, 1923). It is now presented in more detail in an article in the *Annales de Physique* (Paris) for January-February, 1925, abstracted in *Nature* (London), vol. 115, page 549 (April 11, 1925).

†This suggestion was made by Mr. Edmund C. Stoner in an address before the Cambridge (England) Philosophical Society on January 1, 1925, printed in the *Proceedings* of that Society, vol. 22, pages 577-594 (March 12, 1925).

*"Do Electrons Play or Loaf," by Robert A. Millikan. Popular Radio, vol. 6, pages 109-116 (August, 1924).



Courtesy of the Physical Review

WHAT THE SPECTRA OF STRIPPED ATOMS LOOK LIKE

The corresponding pairs of spectrum lines for the different atoms are indicated by the small brackets drawn above and below the photographed spectra. The top strip is the spectrum of sodium, the two crucial lines being marked at the right-hand end. Below, in order, are the spectra of stripped atoms of magnesium, aluminum, silicon, phosphorus, sulphur and chlorine, the last being indicated by brackets alone.

electric sparks passed through a crowd of gaseous atoms of various kinds, Drs. Millikan and Bowen knocked off successively the first, second, third and up to the sixth electron from such atoms as that of nitrogen. The result was a series of important new facts about the properties and structure of these atoms.

Dr. Millikan and Dr. Bowen have now extended these experiments to additional kinds of atoms, including some which have as many as seventeen planetary electrons and from which as many as seven of these electrons have been stripped off by the hot-spark method.[†]

The chief importance of this fact is that it is possible, by this process, to produce a series of partially stripped atoms which differ from each other only in the mass of their respective nuclei. For example, the atom of chlorine, the poison gas first used by the Germans during the war, contains normally seventeen electrons. When seven of these are gone the resulting atoms have ten. Similarly, the normal atom of sulphur has sixteen electrons. Taking six from it leaves, as before, an atom with ten electrons. Finally, the atom of phosphorus has fifteen electrons and can be made to lose five, so that it, too, retains but ten.

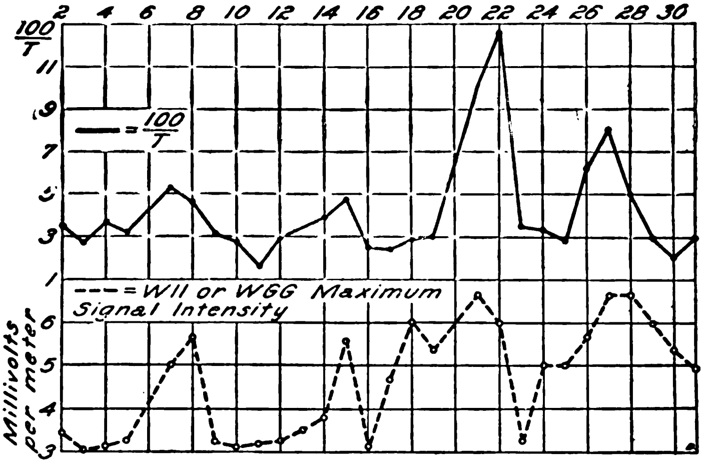
We have then obtained, you perceive, a series of stripped atoms—chlorine, sulphur and phosphorus—each of which has ten planetary electrons. But these atoms still possess their original central nuclei and these nuclei have different masses, or, in common language, different "weights." By examining the light sent out by such stripped atoms, the so-called spectra of the atoms, it is possible to learn much concerning the conditions and orbits of the remaining ten electrons, as well as some things about atomic behavior in general. Measurements of such spectra by Dr. Millikan and Dr. Bowen have supplied substantial confirmation of the famous atomic theories of Dr. Nils Bohr.[‡]

Do Cold Waves Disturb Radio Transmission?

THAT there is "clearly a relation between air temperature and the intensity of radio signals" is the interesting conclusion expressed recently by the *Monthly Weather Review* in its account of a report of Mr. L. W. Austin to the International Union of Scientific Radio Telegraphy.[*]

As a part of the work of this Union, records were kept during parts of 1923 and 1924 of the field strength at the receiving station at the Bureau of Standards, Washington, D. C., of several American radio stations of relatively high power, chiefly WII at New Brunswick, N. J., and WGG at Tuckerton, N. J. A considerable variability of the received field strength was noticed during the cold waves of January 22 and 27, 1924, and during the previous moderate cold of January 7 and 15.

"It is too early," the report continues, "to give any definite explanation of the variations observed. Their cause is evidently atmospheric and the connection with the cold waves of January suggests either that the part of the atmosphere concerned in the variations lies much below the Heaviside surface."



HOW RADIO TRANSMISSION MATCHED THE COLD WAVES

These two curves, taken from Dr. Austin's report, show a surprising correspondence. Temperature is above; radio signal strength is below. The data are for January, 1924.

[†] "The Series Spectra of the Stripped Atoms of Phosphorus, Sulphur and Chlorine," by I. S. Bowen and R. A. Millikan. *The Physical Review* (Corning, New York), vol. 25, pages 295-305 (March, 1925).

[‡] The Bohr theories were described in POPULAR RADIO for April, 1924, pages 319-327, and for December, 1924, pages 546-553.

[*] "Air Temperature and the Intensity of Radio Signals," a review in the *Monthly Weather Review* (Washington, D. C.), vol. 52, page 590 (December, 1924).

Static from Volcanoes

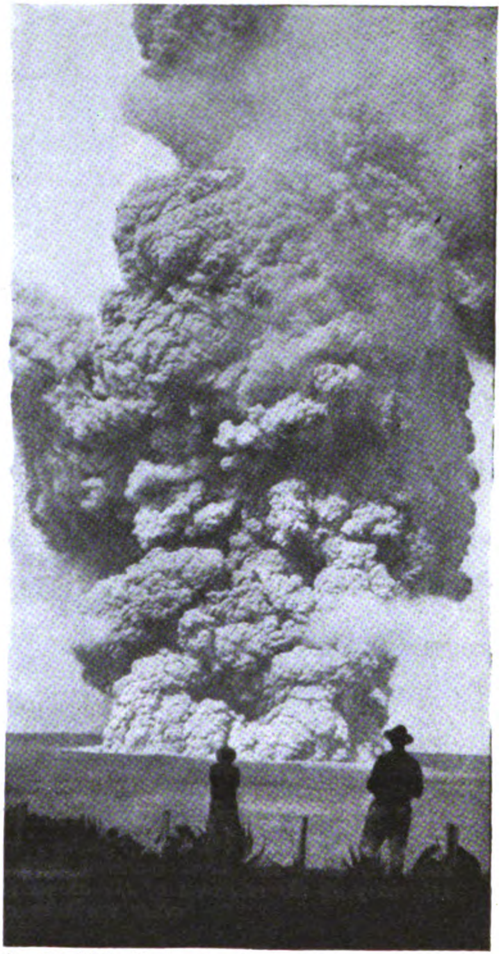
DURING the month of May, 1924, the great volcanic vent of Halemaumau in the Hawaiian Islands displayed a series of explosive spasms more marked than any recorded since the Islands were discovered by the whites. As an incident of these explosions vast clouds of dust were sent up on several occasions for a mile or more into the air. The United States Government now maintains near the volcano a special observatory and a recent report of this observatory is devoted to the May eruptions.*

One feature of this report has considerable radio interest. This is the curve showing the relation between the explosive activity of the volcano and the number of electric storms. There is a clear parallelism. The more explosions, the more storms.

This agrees with the observation often made during volcanic eruptions that lightning can be observed to play through and around the vast clouds of ejected dust. Presumably the friction of the dust particles on each other generate static electricity which is responsible, in turn, for the electric disturbances. A volcanic dust cloud is probably a remarkably successful manufactory of radio static and if the radio fans in Hawaii happened to be tuned in during the eruptions of Halemaumau it is probable that they heard the eruption as well as saw it.

---

* "Volcanic Conditions in May: Seismic Sequences of the Eruption," by R. H. Finch. United States Department of Agriculture, *Monthly Bulletin of the Hawaiian Volcano Observatory* (Honolulu, Hawaii), vol. 12, pages 38-55 (May, 1924).



Courtesy "Scientific American"

ANOTHER STATIC FACTORY

This view of a recent eruption in Hawaii shows the tremendous quantity of dust, all of it more or less electrified, which is shot into the air by volcanic activity.

The Mystery of the Atomic Sun

THE three things in the universe about which we know the least are just these three things which are most fundamental—the three things out of which everything that we know is made. They are the electron, the proton and the "disturbance in space" which we call ether waves.

Matter is made—as everyone knows nowadays—of atoms. Atoms are made of electrons and protons. The protons and some of the electrons form the central nucleus of each atom, the atomic "sun." Other electrons revolve around this nucleus much as the earth and the other planets revolve around the central sun of our solar system. From this atom ether waves go out, at times, as pulses of light. On the other hand, ether waves in the form of light or X rays or even radio waves, can sometimes affect the atom, even to disrupting it. This is the modern picture of the universe, a picture already sufficiently familiar to the readers of POPULAR RADIO.*

Concerning the number, arrangement and motions of the electron planets in the atom we already have a great deal of information. We are learning much, also, about the relations of these electron motions to ether waves, to the so-called spectrum lines with which the different atoms identify themselves in the light that they send out. But about the other essential part of the atom, its central sun or nucleus, our ignorance remains virtually complete.

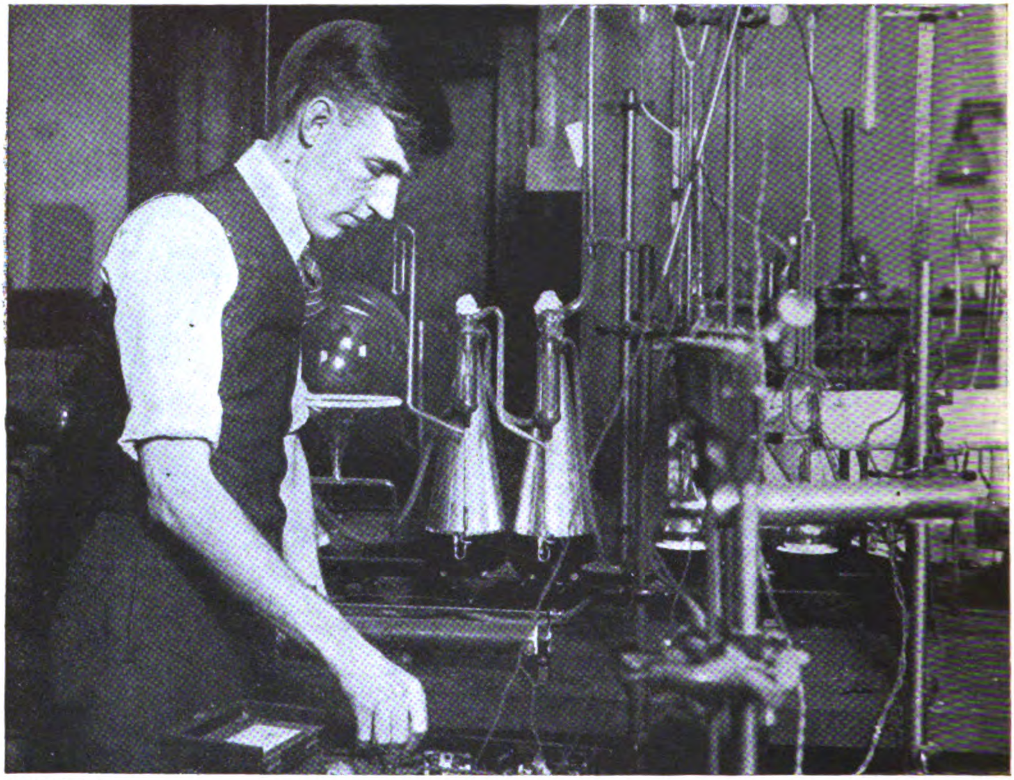
Therein lies the importance of an address made recently before the Franklin Institute, in Philadelphia, by Sir Ernest Rutherford in which Sir Ernest describes what has been learned, most of it by himself and his associates, about the disintegration and transmutation of the chemical elements.†

An instance of natural disintegration is radium, the atoms of which fly apart once in a

---

* See for example, "Bohr's New Theory of Atoms," POPULAR RADIO for April, 1924, pages 319-327, and "Broadcasts from Atoms," POPULAR RADIO for December, 1924, pages 546-553.

† "The Natural and Artificial Disintegration of the Elements," by Professor Sir Ernest Rutherford, *Journal of the Franklin Institute* (Philadelphia), vol. 198, pages 725-744 (December, 1924).



Pacific & Atlantic

AN AMERICAN INVESTIGATOR OF ATOMIC MYSTERIES

Dr. F. S. Mohler, of the United States Bureau of Standards, is one of the American scientists who has been working actively on the facts of atomic structure, especially on the relations of the atoms to the production of light spectra and of other varieties of ether waves.

while, ejecting electrons and other particles with explosive violence. Artificial disintegration of other atoms has been accomplished by Sir Ernest by bombarding them with the fast-moving, very tiny "alpha-particles" shot out by radium and by elements like it. All these facts have been noted in this department.

In his Philadelphia address Sir Ernest summarizes the evidence obtained from these various lines of investigation and proceeds to apply it to the elucidation of that most mysterious problem of what the central suns of the atomic systems are like. In the atom of aluminum, for example, there are a total of 27 electrons and 27 positive particles or protons. All of the protons and 14 of the electrons are crowded together in the atomic sun or nucleus; the other 13 electrons revolve around this nucleus as planets might. The nucleus contains, then, a total of 41 particles, protons and electrons. Nevertheless it is so small, Sir Ernest reports, that its outside diameter cannot be as much as a trillionth of a centimeter, the maximum value being, in figures, 4×10^{-13} cm. This is about one twenty-five-thousandth of the diameter of the aluminum atom as a whole.

If one imagines, therefore, an aluminum atom enlarged so that it is a kind of complicated solar system the outer orbits of which are a mile across, all the protons and half of the electrons will be concentrated in a small central sphere about two feet in diameter. It is the nature of the forces active within this relatively tiny central sphere—the nucleus—that constitutes the greatest present problem of atomic physics.

It is probable, Sir Ernest believes, that these forces within the nucleus are somewhat different from the ordinary electric attractions which control the movement of the planetary electrons and of the larger electric forces which we are familiar with in electrical engineering. There is evidence that the potentials within the nucleus may exceed 2,000,000 volts and that the usual laws for the attraction of unlike charges and the repulsion of like charges may break down.

More important still, there is reason to suspect, Sir Ernest concludes, that an electron and a proton may sometimes unite into a more or less stable combination, forming a sort of monagamous unit which he calls a "neutron." Out of such neutrals, arranged in various ways inside the atomic nucleus, the nuclei of all the various chemical elements may be imagined to be built up.

It is probable that the aggregate of neutrons or of other particles inside the atomic nucleus must be thought of as in vigorous motion, rather than being merely stuck together as though glued each to each by electric attraction. Inside the nucleus, as outside it, the atom is essentially a fragment of motion.

We have been astonished in the past two decades at the succession of discoveries which disposed of the former idea that atoms were mere inert bits of matter, replacing this idea with the concept of the rapid and complicated planetary motion of the outer electrons. The atomic sun, when we thought of it at all, we have passed by as probably merely a clump of protons and electrons. This, it appears, is as far from the truth as was the earlier idea of inert atoms. Inside the nucleus, too, there is a vast and continual activity.

Ultra-short Waves from a Mercury Arc Lamp

Readers of Popular Radio will remember the remarkable experiments of Nichols and Tear in the production of very short radio waves, which experiments Dr. Nichols himself presented to our readers.* By this work the part of the ether-wave series assigned to heat waves and to infra-red light was linked for the first time with the series of electric ether waves like those used in radio.

After the publication of this work in 1923 Dr. Nichols and Dr. Tear continued the experiments. Dr. Nichols was reading a report of them to the National Academy of Sciences, in Washington, when he was taken with the heart attack which caused his sudden death. The complete report of the later work has now been prepared for publication by Dr. Tear.†

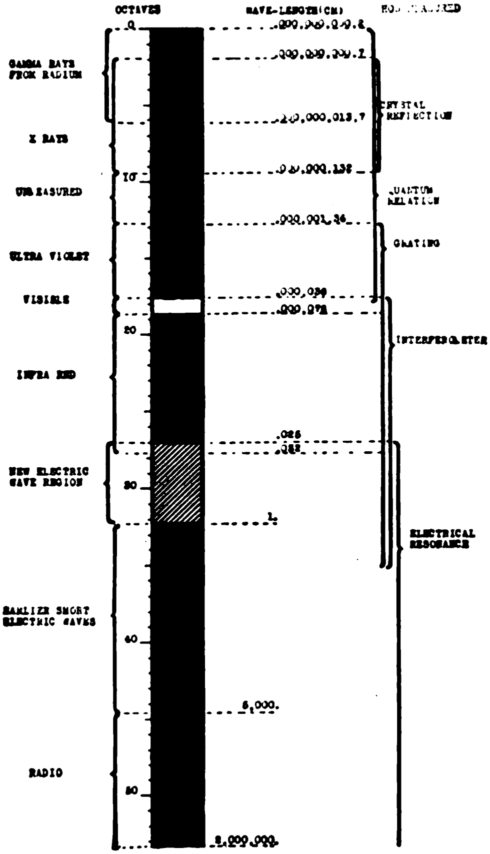
Specialists will find in the new paper some additional details of apparatus and methods not contained in the earlier; preliminary publications of the work. To the radio fan the most interesting new fact is the isolation of electric waves—essentially radio waves—from the "light" sent out by a mercury-vapor arc lamp, the same general kind of lamp as is used by photographers and motion picture producers to provide an intense bluish light.

The light of such mercury lamps contains a number of bright lines in the visible part of the spectrum. Dr. Nichols and Dr. Tear filtered out this visible light by means of opaque screens. They got rid, also, of the invisible radiation lying in the well-known infra-red region, the radiation consisting of waves only slightly longer in wavelength than the waves of visible red light. There was a residue of radiation. This was detected and measured by methods similar to those employed for the very short radio waves and which were described by Dr. Nichols in his paper in Popular Radio.

The result is the detection of mercury-lamp rays having wavelengths as long as .42 millimeter. Since the previous work (since repeated) had led to the discovery of true radio waves as short as .22 millimeter, it is apparent that the mercury lamp has been made to yield ether waves clearly within the true radio range. Thus we have another definite proof of the essential identity of radio waves and light waves.

It is worth noting, too, that the ether wave series no longer provides any gaps to be filled—in imagination—by new and mysterious kinds of radiation. Such unknown "rays" have been dragged in many times to explain facts not yet understood.

It remains possible, of course, that there exist waves still shorter than the gamma rays from radium. Very long radio waves are equally possible. Both ends of the series are perhaps extensible. But there are now no unknown gaps in the middle of it.



Nela Research Laboratories

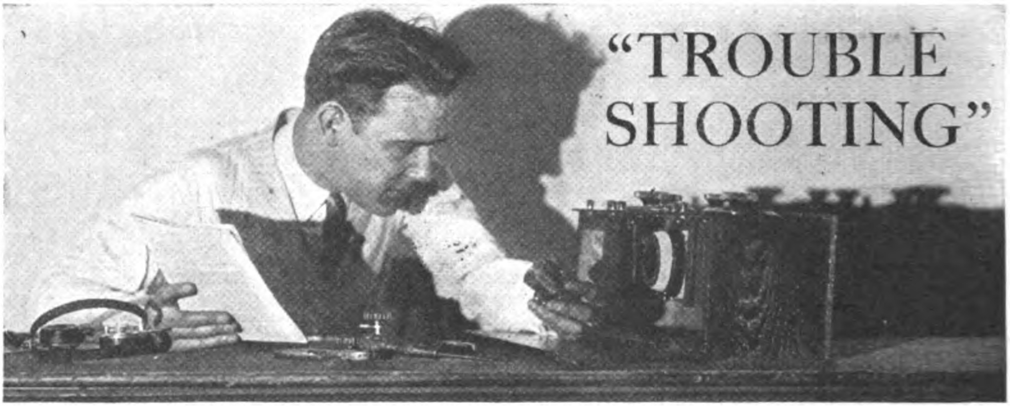
THE COMPLETE ETHER-WAVE SERIES

All the gaps in the ether-wave series have now been filled, as is indicated by this diagram prepared by Dr. Tear.

---

* "The Shortest Radio Waves Ever Produced by Man," by Ernest Fox Nichols. Popular Radio, vol. 4, pages 22-29 (July, 1923).

† "Joining the Infra-red and Electric-wave Spectra," by E. F. Nichols and J. D. Tear. *The Astrophysical Journal* (Chicago), vol. 61, pages 17-37 (January, 1925).



“TROUBLE SHOOTING”

Conducted by S. Gordon Taylor

Every *radio receiver requires a careful balancing of all of its parts if the best results are to be obtained. Two receivers made from exactly the same design may give widely different results, owing to variations in the parts used, the skill of the experimenters and the location of the receiver. This department is conducted for the special benefit of readers who have built the radio receivers described in* Popular Radio *and who want to profit from the experience of others in operating them—to learn the little kinks that get the maximum results.*

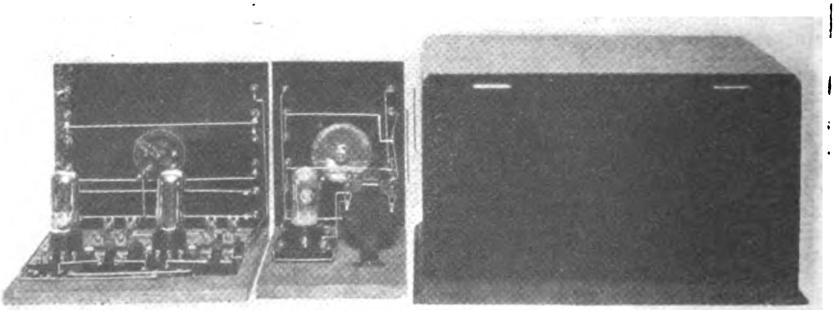
Another Amplifier Combination

In the "Trouble Shooting" department of the June issue the connections were shown for combining the crystal receiver and the one-stage dry-cell tube amplifier which were described in the series of "How-to-build" articles for beginners, in the June and February, 1925, issues.

The beginners' article elsewhere in this issue covers the construction of a two-stage resistance-coupled amplifier which also uses dry-cell tubes. Inasmuch as this new amplifier is especially designed for use in conjunction with a single-stage transformer-coupled amplifier, it works out exceptionally well when added to the combination described in the "Trouble Shooting" department last month.

The combination of these three units will provide good loudspeaker volume of exceptional clarity. The crystal detector is noted for its faithful and distortionless reproduction; and the resistance-coupled amplifier has a similar reputation. For best results, however, it is advisable to use one stage of transformer-coupled amplification between the detector and the resistance-coupled amplification.

In Figure 1 is shown a picture of these three units combined. To effect the combination a slight change was made in the single-stage transformer-coupled amplifier. Binding posts were installed along its right-hand edge to correspond with those at the left. Then by bridging connecting wires directly



THE REAR VIEW OF THE CONNECTED UNITS

Figure 1: *A front view of the combination is shown in Figure 2. Excellent loudspeaker volume of high quality is obtained from this combination of units.*

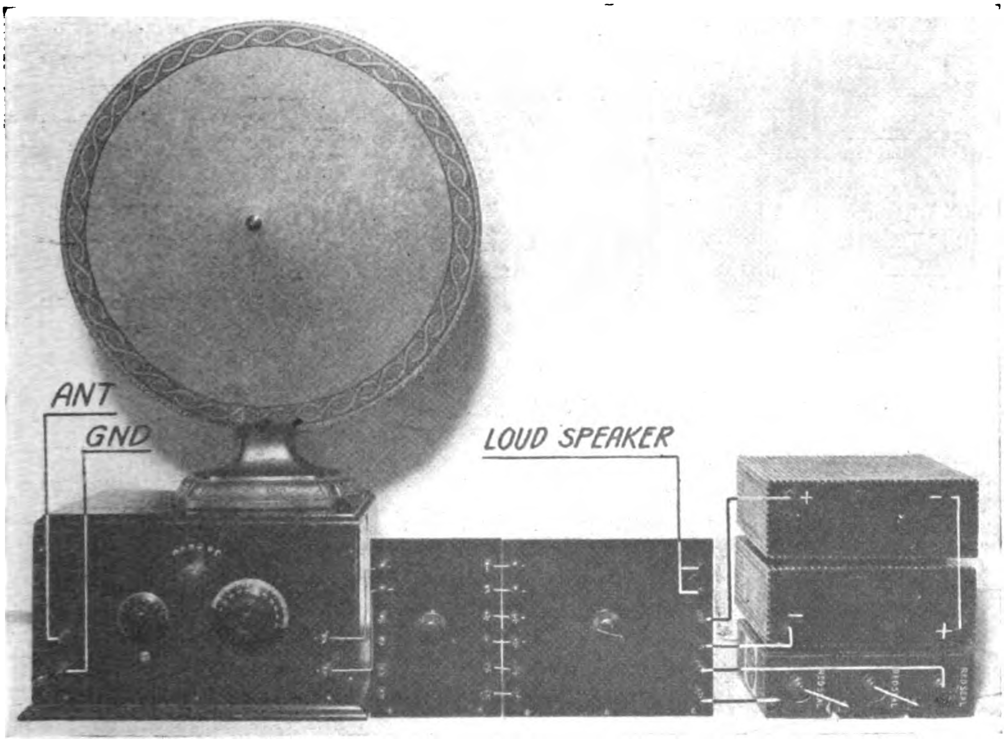
across from one unit to another all are connected to the "A" battery and amplifier "B" batteries. It is then necessary to connect the batteries only to the right-hand end of the last unit as shown. Figure 3 shows the connections for the middle unit after the suggested change has been made in its wiring. The new wiring, which has been added, is shown in dotted lines. The connection between units, and from the end unit to the batteries, are made clear in Figure 2.

In case it is desired to use these two amplifiers with a receiver that has a vacuum tube detector instead of a crystal detector, the connections between the amplifier units, and from these to the batteries, remain the same. In addition, however, the two lower left-hand binding posts of the first amplifier unit are connected across to the two "A" battery binding posts on the detector unit. In that case the binding post on the detector unit which is to be connected to the positive connection of the "B" battery should be made direct to the 22½-volt tap of the "B" battery and not to the "B+" binding post of the amplifier unit. If the "B—" connection of the detector unit is connected to the negative side of the "A" battery, as in the case of some detector units, it will be necessary to use a separate 22½-volt "B" battery for the detector.

Single Control and the Four-circuit Receiver

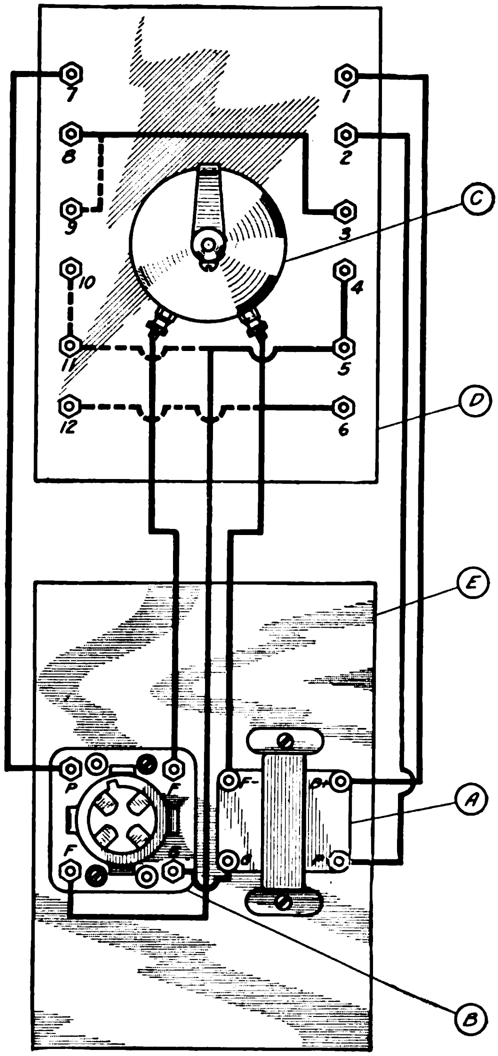
THE following communication from Mr. J. C. Fitzgerald of Oshkosh, Wis., undoubtedly will be of interest to many whose thoughts are straying in the direction of single-control receivers. Mr. Fitzgerald writes:

> "In order to be abreast of the times one must have a single-control radio receiver. For obvious reasons the four-circuit receiver lends itself most readily to this method of control. In order to make such a receiver it is necessary only to use Remler condensers of .0005 and .00035 microfarad capacity instead of the Cardwell condensers specified in the October number of POPULAR RADIO.
>
> "Remove the shaft from one of them (this will determine the position of the



OBTAINING LOUDSPEAKER RESULTS FROM A CRYSTAL TUNER

FIGURE 2: *The units described in the series of "Simple How-to-Build" articles can be combined to produce the results of large receivers. Here is a combination made up of a crystal receiver.* (POPULAR RADIO, *June, 1925*), *a one-tube, transformer-coupled amplifier (described in February, 1925,* POPULAR RADIO) *and a two-tube resistance-coupled amplifier (described on page 14 of this issue). All the connections are clearly shown in the picture.*



CHANGES IN THE PICTURE WIRING DIAGRAM

FIGURE 3: *This drawing shows the single tube transformer-coupled amplifier with the four extra binding posts. The added connections are shown in dotted lines and the original connections in heavy black lines.*

dial on the panel. Take your choice as to which shaft to remove), and mount the two on a piece of $\frac{3}{16}$-inch thick hard rubber or other composition about 4 inches by 6 inches in such a manner that their protruding composition gears intermesh. They should be so arranged on this sub-panel that they make an angle of about 135 degrees one to the other. This will provide plenty of clearance between the plates of the two condensers when they are set at their minimum capacity, i.e., when the plates are all the way out.

"A little care is necessary to mesh the gears so that the plates of the two condensers are set exactly alike. When the condensers have been properly fastened to the small sub-panel, the whole assembly can be fastened to the main panel by means of three or four flathead bolts so placed that the heads are concealed by the dial. A 6-volt, .3 ampere Walbert 'Panelite' in series with the 'A' battery switch, and placed directly above the dial, provides excellent light for tuning and shows when the set is turned on.

"With this condenser arrangement no vernier dial is necessary. The regular Remler dial rotated through three hundred and sixty degrees provides for fine tuning. The selectivity, volume, sensitivity, and tone quality are at least as good as when other condenser arrangements are used.

"By studying the accompanying photographs, it will be noted that the Bradleyohms are mounted on a shelf behind the panel. This shelf is supported by brackets fastened to the baseboard. It will also be noted that a universal Bradleystat is used to control the filament of the last audio tube. This enables one to use different tubes without the bother of changing amperites. A 216-a tube seems to be best in this stage. The jack was omitted from the first stage of this receiver because it is in use in a locality that has no big broadcasting station within a radius of 200 miles. The jacks in the last two stages are of the filament control type.

"The new Sodion tube (type D-21), used as a detector in this set seems to give as much volume and better tone quality than the usual UV-200 and uses only ¼ ampere current.

"The two turns of 'A' coil shown in the pictures are shorted so they are in effect only one turn.

"A small fixed condenser in multiple with the last ½ meghom resistance sometimes stops a high-pitched whistle that occasionally bothers in the last stage of four-circuit tuners. This trouble is sometimes due to mechanical coupling between loudspeaker and set. In the set pictured the loudspeaker unit, as well as the horn, rests on pieces of sponge rubber so as to minimize the transmission of mechanical vibration to the set."

This single-control tuning arrangement suggested by Mr. Fitzgerald is an entirely practical one—especially as the four-circuit tuner is particularly adaptable to the single-control principle. Some of the other changes mentioned by Mr. Fitzgerald may also prove helpful to owners of four-circuit receivers.

The use of the Sodion tube (D-21) as a detector in this circuit has given satisfactory results in some cases but in others does not seem to work out well. Also, the use of a lower resistance in the grid circuit of the last tube—either .25 or .1 megohm—will usually eliminate any whistle there may be when the fifth tube is used. This remedy is considered better than the use of a fixed condenser.

The Five-tube AC Receiver

(This set was described in POPULAR RADIO *for June, 1925)*

THE current supply for the heaters of the five tubes is obtained from the 110 volt AC house lighting lines, through a small step-down transformer. Such transformers are designed to deliver the specified output voltage on 110 volt input, and will continue to deliver sufficient output voltage even though the input voltage, or the voltage of the lighting lines, may be somewhat less than 110. However, if the line voltage is too low the output voltage will also be too low for proper operation of the AC tubes. In some localities, for instance, the line voltage may not be more than 100 or 102 volts, and in such cases it is quite probable that the transformer will not deliver sufficient voltage to operate the tubes at maximum.

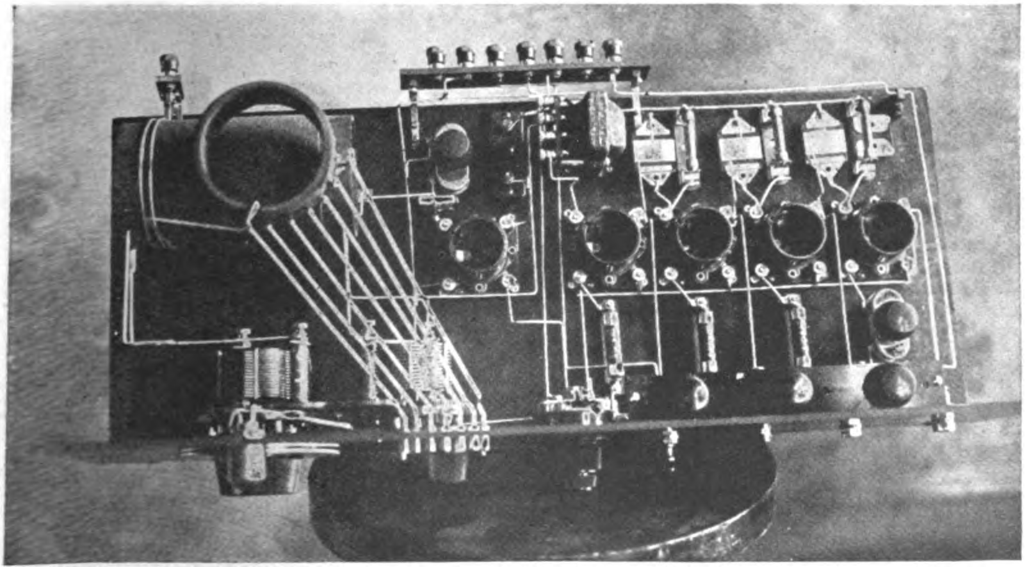
In view of these conditions it is essential that the transformer used with the AC receiver be capable of delivering proper output voltage regardless of how much the line voltage may vary from 110.

A further condition required in the transformer is that the voltage variation between taps be small. Transformers which have a variation of one volt or more between taps are not suitable. The voltage should be variable in steps of about one-quarter volt.

The transformer mentioned in the article in the June, 1925, issue (Dongan type B-Special Transformer) has proved satisfactory for use with these AC tubes. It is capable of taking care of line voltages from 100 to 120 or even lower or higher than this. The tap switch which is mounted on the transformer includes five taps to vary the output voltage in steps of approximately two-tenths of a volt. Three output terminals are also provided on this transformer instead of two as shown in the June issue.

Where the line voltage is 110 or lower the leads from the tubes are connected to the two outside output terminals on the transformer. If the line voltage is higher than 110 the leads from the receiver are connected to the left hand and center terminals of the transformer (with the output terminals toward the observer).

In most cases a voltmeter suitable for measuring alternating current voltage will not be available, but the proper connections to the transformer can be determined by trial. If the output voltage is too high the receiver will tend to oscillate. On the other hand, too low voltage will result in decreased volume and probably an audible hum.



HOW THE TWO VARIABLE CONDENSERS ARE MESHED TOGETHER

FIGURE 4: *The baseboard layout is almost identical with that of the four-circuit receiver with resistance-coupled amplifier described in* POPULAR RADIO *for October, 1924. The only variations from the original receiver are in the arrangement of the Bradleyohms and the variable condensers.*

International

REGULAR BROADCASTING MAKES ITS OFFICIAL DEBUT IN THE FLOWERY KINGDOM

The "radio craze" swept over Tokyo, Japan, with the inauguration of regular broadcasting late in March. This snapshot shows some of the crowd that collected about the loudspeakers that were set up in front of the more progressive shops.

The BROADCAST LISTENER

Comments on radio programs, methods and technique —from the point of view of the average fan

By RAYMOND FRANCIS YATES

WHILE writing flattering paragraphs sprayed with Chypre is several hundred meters from being our oyster, we are really not as bad as some of our readers try to make us out. God knows, there is not a vistage of egg on our vest, we do not use a skullcap or a snuff-box and the knees and seat of our trousers are far from being shiny. The trouble is, it seems, that too many people take us seriously thinking that we are putting on a superior critical air with the avowed intent of showing the broadcasting industry that it is a very rank and a very junky affair.

As a matter of fact, that is a long way from our aim.

In the first place, who are we to dispute the artistic sense and theatrical judgment of our keen, studious and very alert directors of the radio? A lot of nerve we have to question the talent of the great big minds back of broadcasting. The very thought of it makes us feel weak and mean. What we are really trying to do, Dear Reader, and what we will do, if you will laugh a little with us instead of writing very saucy letters about our sarcasm, is to make ourselves ridiculous by attempting to criticise something that is safely out of the zone of our esthetic sensibilities. It is our most sincere ambition to be another Merton of the Movies in the field of radio criticism and if we want to suffer through the mental anguish and the sacrifices that this entails, all's well and good. That's our business. Keep right on writing your nasty letters if you must, our cross is not too heavy to bear!

* * *

Honors to WJZ

ANY broadcaster that will install a portable transmitter on a yacht in an effort to supply its listeners with the steaming hot news of a boat race, is, to our way of thinking, an institution dedicated to public good. During the Cornell-Princeton-Pennsylvania races, WJZ was Johnny-on-the-Spot with a small radiator (radio type) placed on an Elco crusier in the care of Major Andrew White. While the voice was a trifle mushy, the effort was essentially a pioneering one, and deserves nothing but sincere praise.

* * *

Rating the Announcers

THE professors of New York University set out on a classical piece of research when they called together all of the New York station announcers to study their voices scientifically and to give them each a ticket telling them just where they stood on the scale of acoustic importance. The exhaustive data which they recently laid before the studio managers, were accumulated by the aid of a phonographic recorder into which each young man poured his silver voice for future reference.

It is said that Mr. McNamee won the contest by four-tenths of a point, which means very little to this gray old head.

Brokenshire, who patronizes thousands daily from WJZ and who, had the contest been based on vocal cocksureness, would have put all competitors to shame, was a very close second. Mr. Granlund (NTG, WHN), this department is sorry to report, made a very poor showing, pulling up to about seventh place. Even the professors of N. Y. U. should know that you cannot expect too much of a phonograph record.

We have no desire to demonstrate sympathy with the aims of the learned men who designed and executed this unique contest. The results, though painstakingly gathered, amount to so much twaddle to this reckless old dumbbell. When somebody tells us that Mr. McNamee has a frequency superiority of four-tenths of a point over Mr. Brokenshire we find it difficult to prevent ourselves from lapsing into a prolonged fit of laughter which would be strictly against the doctor's orders. We can appreciate Nurmi doing a hundred yards in 9.16 but when Mr. Brokenshire is said to do a "Good night" in 86.9 (the meaning of this figure is still a total mystery) we feel like curling up in some cozy little corner and purring ourself to sleep.

We cannot help but believe that our experimentally inclined professors made a serious mistake in this matter. The announcing material with which we have to work runs so low in grammatical and vocal efficiency that it is pure nonsense to compare one announcer with the other. One might just as well compare the cackle of a white leghorn with a pullet or the bark of a fox terrier with its miserable brother, the pomeranian. If several hundred new voices had been tested and labelled (not that the testing and labelling means a great

Kadel & Herbert

"AND THEN JOHNNY WOODCHUCK SAID—"

The days of summertime radio are upon us, and more receivers than ever are now being operated in camps, where the voices of the city penetrate when the day's work is over. These fair vacationists are tuning in on a cot-time story.

deal) there might have been found a large number of persons who could express themselves more pleasantly, more feelingly and more intelligently than any one of our present announcers. If announcing is to be improved, experimental material must come from without, not from within.

* * *

Why Newspapers Are Wary of Broadcast Artists

THE American Newspaper Publishers Association, always wary of the radio business, has recently decided that newspaper columns will remain closed to those who advertise on the air. No matter how beautifully the Eveready Trio or the Goodrich jazz band plays, and no matter how badly the readers of any particular paper desire to distinguish these music makers from all the rest of the orchestras and trios listed, no effort will be made to extend this service.

The greatest object of any newspaper, we have always been told by the big publishers, is that of giving service to its readers. Of course, we have always known that this is largely distilled bunk and that the sole object of any paper is that of landing the big national contracts. Service to the reader is carried only to the point necessary to hold the patronage of the largest number of people possible.

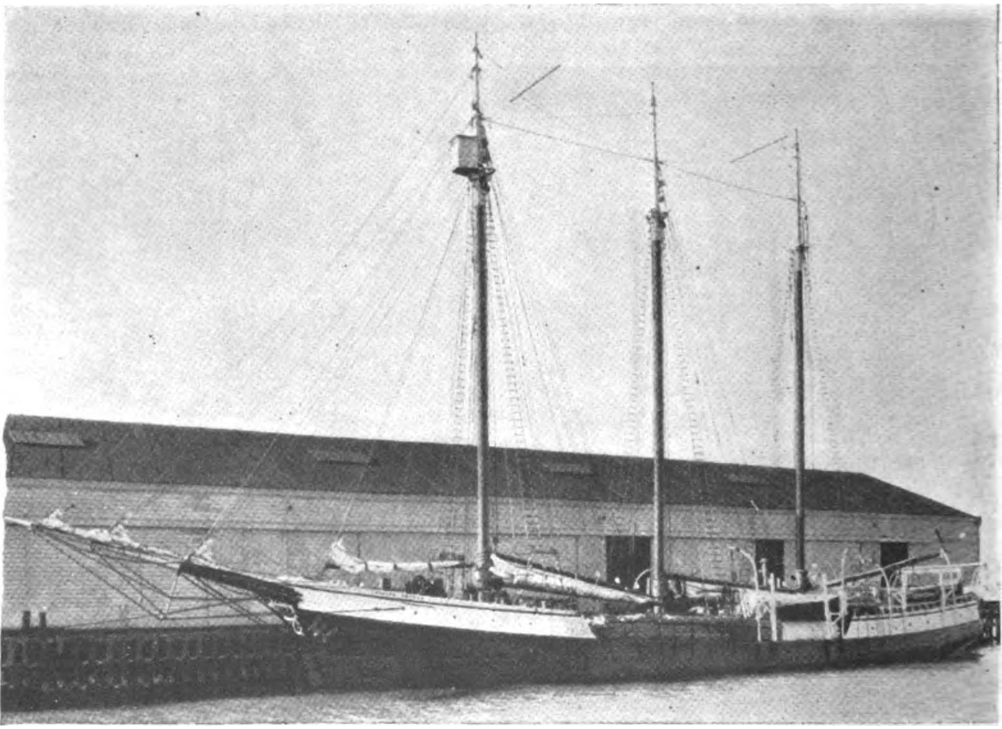
National baseball is the biggest advertised industry in the United States, but our newspapers do not seem to object to turning over tons and tons of white space daily to help fill the pockets of the baseball magnates. Radio is not the greedy user of space that baseball is, but our publishers, those great big-hearted fellows who burn with the desire to be of service to their fellow men, seem to begrudge every square inch of type space devoted to the subject.

The decision of the N. A. P. A. to omit the names of orchestras, unless they are paid to publish them, really shows just how much is thought of the "reader first" ideal to which so many of our publishers hold—for business reasons.

* * *

WE quote from the *Visitor*, a religious publication circulated in the city of Providence, R. I.:

"May we hope to be pardoned for expressing a very personal opinion of America's wishy-washy, good-goody man, one Roxy? In things that are blatant and banal he is the supreme offender. How can a man be



RADIO EMBARKS ON SCIENTIFIC EXPEDITIONS

One of the real services rendered by radio has been to arouse public interest in the activities of explorers. Like the MacMillan expedition, this little vessel, the CHARLES BOWER, *is keeping the fans in touch with its adventures in the far north, by means of its transmitting apparatus.*

expected to sleep nights having listened to his foolish sentimentality? How on earth is it possible for anyone to stomach Roxy's idiotic blessings and benedictions. We always see Roxy the alert business man behind his words. We have tried our best to throw the mantle of charity over this piously-inclined entertainer, but we never turn from the radio without a picture of Roxy's leer."

When an idle muser in type aims a squirt of nasty ink at Roxy, we usually get pretty well boiled up over it. As might be expected from most religious bigots, it seems that the ordained have a monopoly on blessings and benedictions and that should anyone outside God's handpicked followers communicate an honest blessing to his fellow men, he must be a shameless hypocrite and a soothsayer. Just remember this, because if you have not got a holy license to wish a friend well, you must be purveying your kindness for business reasons.

That the writer of this malicious item never turns from the radio "without a picture of Roxy's leer" admits very little for so pious a gentleman. Where is his tolerance, his professed Christianity? Where is his optimism; his well wishing? We could go ranting like this for a dozen pages, but that would be a silly thing to do. If we exploded every time we read the bigoted effusions of minds in religious strait-jaackets, we should be kept pretty busy nowadays. Perhaps it would be just as well to permit J. Frank Chase (Mr. Chase sent us the clipping), Secretary of the New England Watch and Ward Society, to come to the defense of Roxy. The letter says in part:

"In a Metropolis where recently thirteen plays were claimed to be questionable and where scarcely a theater has escaped the scrutiny of censoring, 'Roxy' manages perhaps the largest theater in the world with three packed houses a day, and each performance 'as clean as a hound's tooth.' Nothing offensive, nothing suggestive, nothing morally tainted, has ever, so far as I know, been witnessed at the Capitol, and yet it is a financial success and that in a city where it is claimed a 'classy show' is the only one which pays.

"The writer of the offending article calls Roxy in the face of that miracle America's wishy-washy, good-goody man. I say Roxy is a proven genius—he is doing in his field in a fine, clean, manly way a miraculous piece of work. That man who can amuse his fellows with clean, wholesome recreation is a great public benefactor.

" 'But he makes money out of it.'

"Well, suppose he does. It is better than making money out of the filthy. The man who can make clean things pay today is a supergenius, if theatrical managers are sound in their contentions.

"As to his 'foolish sentimentality,' that opinion indicates the writer is lacking in humanity and has lost the milk of human kindness. The sentiment of Roxy is the manly, gentle type that a man feels when he speaks of 'Mother.'

Kadel & Herbert

A "NON-BREAKABLE" VACUUM TUBE

A demonstration of the new ¼-ampere bulbs that are designed to reduce the losses due to breakage by radio fans.

"I have been a constant radio fan and have yet to hear Roxy utter any weakly sentimental stuff. In fact, he eschews such stuff. Perhaps his conversation with his artists may be what is alluded to. If so, I may say that all his artists highly respect and esteem him. He is the kind of big brother that awakens the intensest loyalty. Recently when a new member sang her first song, it was plain that she had stage fright and wasn't doing herself justice. It was wonderful to hear him restore her confidence by an encouraging word: 'Now relax and be yourself, and try another one,' and I imagine there was a pat on the shoulder, but when she sang at once again the miracle had been accomplished, and the tones were fine, firm and very true and correct. Roxy has the genius to discover merit and develop it by kindness.

"But it is not artistic merit alone he develops. He has the genius to keep all around him ambitious to be true and noble. A medical friend of mine who visited New York a few days ago commented on the artificialty of New York women with their paint and powder, but he said 'I went to the Capitol and met Roxy's girls and found them different from other Broadway girls."

WITH THE INVENTORS

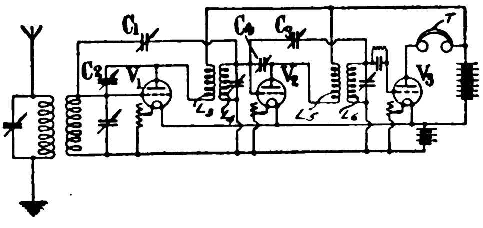
CONDUCTED BY WILLIAM G. H. FINCH

THIS *department will keep you in touch with the latest inventions of interest on which patent rights have been granted, and which are significant contributions to radio art.*

A Neutralized Tuned Radio-frequency Receiver

RECEIVERS that employ two or more stages of radio-frequency amplification that involve the use of two or more circuits tuned to the incoming frequency, and arranged so that each of two plate circuits has a tuned circuit that is associated with it either by coupling or direct connections, sometimes produce undesirable reactions or self-oscillations. This tendency toward self-oscillation is due largely to capacity coupling in the tubes themselves.

John Scott-Taggart of London, England proposes, in the patents, Nos. 1,524,580 and 1,524,581, to eliminate this evil by the proper use of condensers that are connected in the circuits as shown in Figures 1, 2, and 3. These condensers produce a reverse reaction effect that neutralizes the tendency of the radio-frequency amplifier to generate oscillations, thereby eliminating the "squealing" that might otherwise result.



THE NEUTRALIZED TUNED RADIO-FREQUENCY CIRCUIT

FIGURE 1: *Scott-Taggart's "neutrodyne" or neutralized tuned radio-frequency. C1, C2, C3 and C4 are neutralizing condensers.*

Vacuum Tubes in Transatlantic Cable Reception

THIS invention covers a system for receiving and for definitely and sharply discriminating between signals in the form of current impulses or waves varying in amplitude.

In numerous telegraph signaling systems intelligence is conveyed by code impulses differing from each other and arranged in various combinations to represent letters of the alphabet. These impulses are distinguished from each other by the employment of code combination impulses that differ in potentive. If the live impedance is substantially constant, these impulses also differ to the same degree in current strength. At the receiving station, in order that the impulses may be translated into observable form or recorded, it is necessary to provide apparatus which will discriminate between impulses varying in current strength.

This patent, No. 1,514,753, was issued to Peter I. Wold of Schenectady, N. Y. and the circuit for it appears in Figure 4. This diagram shows how cable service has to depend on radio apparatus for best operation.

Because of slight variations in the line impedance and in the electrical characteristics of the line, impulses differ in current strength when impressed upon the line at the transmitting end, reach the receiving apparatus somewhat distorted and the actual difference in current strength between succeeding impulses may be insufficient to enable the ordinary receiving apparatus to translate or record them in intelligible signals. This is a big factor in transatlantic cable communication.

This difficulty can be eliminated by this invention and discrimination between signaling impulses is made certain by interposing between the usual recording and translating devices at the receiving station and electrical network in the nature of a marginal relay. This device responds, not in direct proportion to the strength of the received current, but discriminates between small variations in current strength and substantial differences besides.

A network having a stepped characteristic is provided by utilizing a number of vacuum tubes connected in parallel, each of which is arranged to pass currents between certain definite limits of current strength.

A Novel Variable Condenser

CARL A. HELLMANN of Washington, D. C. has invented a novel variable condenser (Patent No. 1,525,778) wherein a useful variation of capacity may be had over an angle of rotation exceeding 180 degrees and approaching as near to 360 degrees as may be desired in any particular case.

Another feature of this condenser is that it has several distinct ranges of capacity, which may be readily selected for service by mechanical or electrical means, or by both together.

A Handy Radio Cabinet

A NEW style of construction for a radio cabinet has been patented to cover mounting the receiving apparatus on a slidable sub-base which is supported in suitable grids upon the base proper of the cabinet, resulting in quick and easy positioning and access to the apparatus mounted thereon. The patent is number 1,527,896 and was granted to Samuel L. Miller of Chicago.

A Convenient Design for a Radio Receiver Cabinet

PATENT No. 1,528,473 issued to Joseph B. Edwards of Chicago relates to a cabinet which will permit its top, rear or front part to be removed independently of the other to permit access to the various pieces of apparatus mounted in same.

This type of cabinet construction should prove popular among those experimentally inclined because of the ease with which one can quickly make an inspection or any changes desired.

A New Modulation System

A NEW radio phone modulation system is disclosed on patent No. 1,528,047, issued to Frank Conrad of Pittsburgh, Pa.

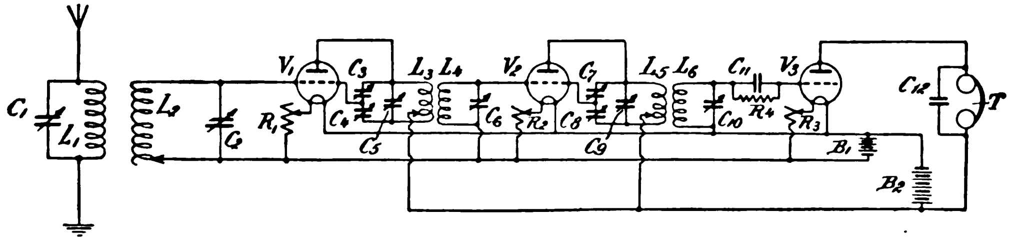


FIGURE 2: *Another modification of Taggart's invention, showing positions of the various neutralizing condensers in an inductively coupled radio-frequency amplifier circuit.*

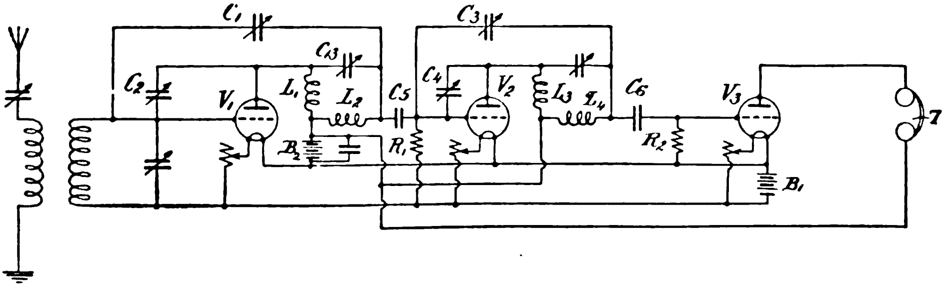


FIGURE 3: *A modified circuit arrangement in which the tubes are capacitatively rather than inductively coupled.*

A Novel Grid Condenser

A new patent discloses a method of employing the base of a tube in such a manner that the base forms an integral part of the grid condenser and at the same time provides a convenient means for connecting the grid condenser in the grid circuit. Figures 5 and 6 show how the dielectric material 13, such as mica, is held in place by the metal element of the condenser in the form of a copper band 10 which is clamped around the tube base by the means of a bolt and nut. This patent was granted to Robert C. Pitard of Jackson, Miss. under the number 1,523,893.

A New Radio Transmission Idea

In patent No. 1,468,250, S. O. E. T. Trost of London, England, suggests a scheme for impressing two oscillations on the antenna in such manner that they are opposite in phase. They therefore neutralize each other. Modulation consists in varying the phase of one of the oscillations so that the neutralization is no longer perfect. Thus a signal is sent out.

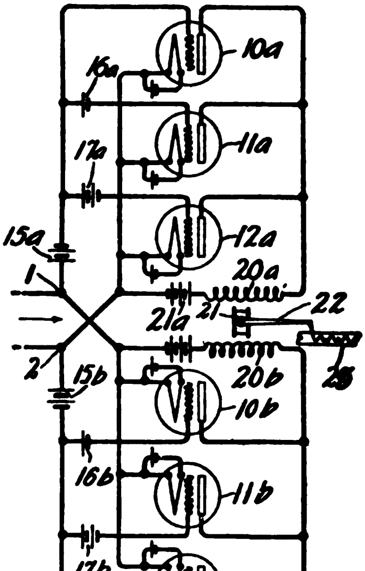


Figure 6: *Peter I. Wold's method for definitely and sharply discriminating between received signals.*

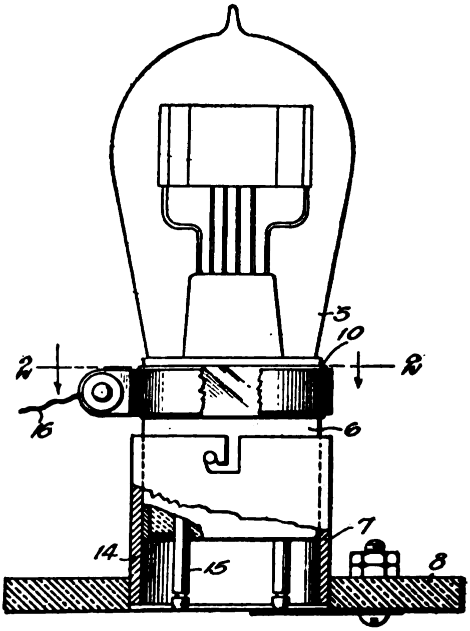


Figure 5: *A view partly in elevation and partly in section of a grid condenser showing how the base of a vacuum tube is employed as one of the elements of the condenser.*

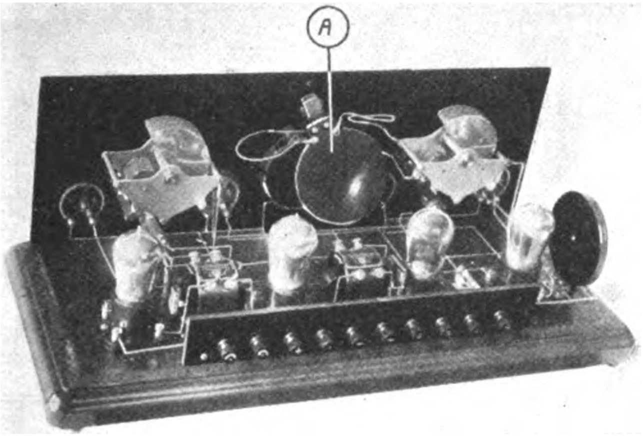
A Short Range Radio System

This patent, No. 1,470,088, is a suggestion for the use in radio signalling of much longer waves than any now employed, waves the frequencies of which approach those of ordinary alternating currents. Frequencies of 500 to 1,000 cycles are suggested, corresponding to wavelengths of 600,000 to 300,000 meters. It is claimed by the inventor, Fritz Lowenstein of New York, that these very low-frequency waves have utility in signalling over short distances, as for example, between the ships of a fleet at sea, and that they do not travel far enough to produce interference at a distance or to be readable by distant enemy stations.

The New Birch-Field Receiver

The illustration on page 187 is that of a four-tube receiver embodying the new Birch-Field tuning unit, patent No. 1,488,310, designated "A" (Figure 7).

In radio receiving sets generally and more particularly in the less expensive sets, considerable difficulty is encountered in the reception from stations at a distance and even in stations close by, due among other things to a lack of sharp tuning capabilities in the parts of such sets, and among the more important objects of the invention is the provision of a receiving set which, while simple in construction and operation and inexpensive in cost, is



THE RECEIVER WITH THE NEW INDUCTANCE UNIT

FIGURE 8: *The coil unit shown at A permits the variation of coupling between the primary and secondary from the outside of the cabinet, which has been removed for the photograph.*

nevertheless capable of very sharp and quick tuning and very efficient detuning.

Where such receiving apparatus employs the inductive relationship of two induction members such as coils, it is obvious that the efficiency of the inductance will be dependent upon the extent to which the secondary cuts the lines of force about the primary, and this is a prime consideration in the mounting of induction members.

The inductance members "A" are so related and associated that the secondary may be positioned in any desired portion of the field about the primary; the provision of inductance members so associated as to permit of their variation in position relatively to each other, so as to give maximum inductance, thereby resulting in rapid and sharp tuning, which is due to the way Birch-Field has mounted and associated the inductance or tuner units which permit a variation of their relative positions in more than one plane, and more particularly to permit of such variation by the operation of but one control; and permitting of angular variation of the inductance there between; and in a plurality of planes, one or more of the pancake type inductances are employed.

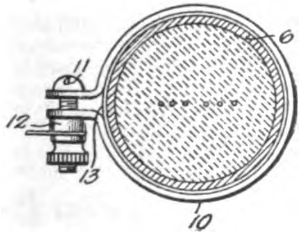


FIGURE 7: *A top view of the drawing of Figure 5, in which 6 is the tube base, 10 is a metallic band and 13 is a band of dielectric material.*

Such a structure provides a method of obtaining high efficiency, simplicity and sharpness in tuning at very low cost.

Radio Picture Transmission

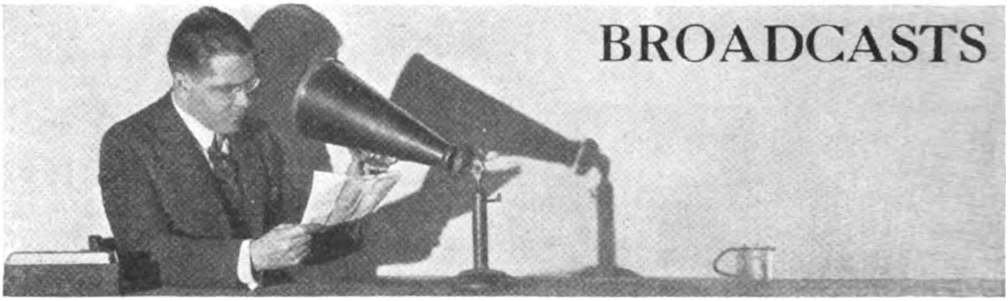
C. FRANCIS JENKINS, of Washington, D. C., in another of his patents (No. 1,533,422) discloses an apparatus for the transmission of photos, maps, and photo-messages by radio, and has for its principal object a construction permitting continuous operating at high speed over an extended period. Another object is to secure a high degree of efficiency of the incoming radio signals, with as nearly perfect modulation as can be attained.

A New Method for Manufacturing Condensers

A PATENT was granted to W. R. Respess of Staten Island, for a method of manufacturing condensers, patent No. 1,533,611, in which the metallic plates of a condenser are coated with a dielectric film.

A Method of Eliminating the "B" Battery

For several months the POPULAR RADIO LABORATORY *has been working on the development of a "B" battery eliminator. The subject will be shortly treated in a constructional article in a near issue of this magazine.*



BROADCASTS

CONDUCTED BY DAVID LAY

ITEMS *of general interest that you ought to know; bits of useful information that every radio fan ought to know.*

Radio vs. Barroom Stories

THE placing of radio receiving sets in British "pubs"—as the English call their cafés, has received official commendation from a magistrate in Cornwall. An application for installing a radio receiving set in a public bar came to the attention of a magistrate who, in passing upon it, said that it was desirable that radio sets be installed in pubs, on the grounds that it would be far better for people who came to drink to listen to the educational matter broadcast than to sit about telling barroom stories.

* * *

Insurance Company Broadcasts "Health"

A RADIO "gym" has been opened by the Metropolitan Life Insurance Company in New York City, and from it setting-up exercises are broadcast daily through stations WEAF, New York City, WCAP, Washington and WEEI, Boston. The exercises go on the air at 6.45 A.M. for one hour. They are divided into three separate classes of twenty minutes each, beginning at 6.45, 7.05 and 7.25 o'clock. This early morning program is supported by the distribution of exercise charts and other literature that is designed to give a full measure of health value to the broadcasting. The exercises are conducted to music and timed to a cheerful tempo.

* * *

Peru Starts Broadcasting

RADIO broadcasting was started in Peru in March. The first station to be built in that country is at Lima; it is a duplicate of the famous London station 2LO, that was located at Marconi House. The Peruvian station's call is OAB and its transmitting wave 360 meters. About a thousand radio receiving sets have already been shipped to Lima from the United States.

Sweden Gets the Fan Fever

SINCE the first of the year, when daily radio broadcasting service from the new stations in Gothenburg and Palmo in Sweden were started, four thousand fans have taken out licenses in Gothenburg alone. It is reported that about 11,000 crystal receiving sets, 30,000 headsets, 4,000 tubes and almost 1,000 complete receiving sets, together with a large quantity of parts of all kinds, which amount to almost $300,000, were sold in a couple of months in Gothenburg.

* * *

Theatrical Managers and Broadcasters End Fight

THEATRICAL managers in England have agreed to give up their fight against broadcasting, on the condition that the company restrict their theatrical broadcast to twenty-six per year. In addition the British Broadcasting Company agrees never to broadcast first nights. It is also agreed that the portions of a play that are broadcast shall not take up more than twenty-five minutes in all. This may be taken all at once, or split up among the various acts.

* * *

What Parisian Fans Pick Up

BROADCASTING is carried on in the Paris district by the Eiffel Tower, the Société Française Radio-Electrique and the Superior School of the Postal, Telegraph and Telephone Services of the French Government, reports John Farr Simons, of the American Consulate in Paris to POPULAR RADIO. The wavelength used by the Eiffel Tower is 2,650 meters; the principal items broadcast are weather reports, stock exchange news and a radio concert every evening. The wavelength used by the Société Française Radio-Electrique is 1,750 meters, which broadcasts two radio concerts, one in the afternoon and the other in the evening. The Superior School broadcasts on a wave of 458 meters; its program includes educational subjects and an evening concert.

Weather Forecasts by Radio

Here is a list of the radio stations in the United States and territories which are broadcasting the official weather forecasts in co-operation with the United States Weather Bureau at Washington, as compiled by B. Francis Dashiell. As the weather forecast for the State in which the listener resides is almost always the only one desired, it is necessary merely to tune in for the nearest station that broadcasts for the State—setting the radio receiver at the indicated wavelength at the scheduled broadcasting time. All time used is local for the station indicated. The list is alphabetically arranged by cities, giving the stations, wavelength and local broadcasting time; the time stated is Standard Time.

LIST OF STATIONS THAT BROADCAST WEATHER FORECASTS

City	*State*	*Station*	*Wavelength*	*Time of Broadcasting*
Altoona,	Pa.	WFBG	278	10.30 P.M.
Ames,	Ia.	WOI	270	9.45 A.M. and 9.30 P.M.
Atlanta,	Ga.	WSB	428	11.55 A.M. and 10.00 P.M.
Auburn,	Ala.	WSY	250	12.00 Noon.
Austin,	Tex.	WCM	268	10.30 A.M. and 4.00 P.M.
Baltimore,	Md.	WCAO	275	12.00 Noon.
		WCBM	229	10.00 P.M.
		WGBA	254	2.00 P.M.
Boise,	Ida.	KFAU	275	3.15 P.M.
Boston,	Mass.	WGI	261	5.30 P.M.
		WNAC	280	11.00 A.M.
Breckenridge,	Minn.	KFUJ	242	9.30 A.M. and 3.30 P.M.
Buffalo,	N. Y.	WGR	319	10.45 A.M.
Canton	N. Y.	WCAD	263	11.00 A.M.
Charlotte,	N. C.	WBT	275	11.00 A.M.
Chicago,	Ill.	WAAF	278	10.30 A.M.
		WGN	370	9.00 A.M. and 10.25 P.M.
		WLS	345	9.00 A.M. and 10.00 P.M.
		KYW	535	1.00 P.M. and 11.30 P.M.
Cincinnati,	O.	WLW	422	10.30 A.M.
Cleveland,	O.	WEAR	389	11.00 A.M. and 3.00 P.M.
Columbia,	Mo.	WAAN	254	12.00 Noon.
Columbus,	O.	WBAV	294	11.30 A.M.
		WEAO	294	12.30 P.M.
Dallas,	Tex.	WFAA	476	10.30 A.M.
		WRR	261	12.00 Noon and 5.45 P.M.
Davenport,	Ia.	WOC	484	1.00 P.M. and 9.00 P.M.
Denver,	Col.	KLZ	283	8.30 A.M. and 7.55 P.M.
		KOA	322	1.00 P.M.
Des Moines,	Ia.	WHO	526	9.30 A.M. and 12.00 noon.
Detroit,	Mich.	WCX	517	10.15 A.M.
		WWJ	353	11.25 A.M.
Devils Lake,	N. D.	WDLR	231	12.00 noon.
Evansville,	Ind.	WGBF	217	11.15 A.M.
Fargo,	N. D.	WDAY	244	10.30 A.M.
		WPAK	275	10.50 A.M.
Fond du Lac,	Wis.	KFIZ	273	4.00 P.M.
Fort Worth,	Tex.	WBAP	476	11.00 A.M. and 9.30 P.M.
Fresno,	Cal.	KMJ	248	8.15 A.M.
Galveston,	Tex.	KFLX	240	10.30 A.M.
Grand Rapids,	Mich.	WBDC	256	12.15 P.M.
		WEBK	242	10.00 A.M.
Havre,	Mont.	KFBB	275	12.30 P.M.
Honolulu,	T. H.	KGU	360	7.30 P.M.
Hot Springs,	Ark.	KTHS	375	9.45 A.M. and 9.30 P.M.
Houghton,	Mich.	WWAO	244	11.00 A.M.
Houston,	Tex.	WEAY	360	11.00 A.M. and 9.00 P.M.
Indianapolis,	Ind.	WFBM	268	10.15 A.M.
Jefferson City,	Mo.	WOS	441	11.00 A.M.
Kansas City,	Mo.	WDAF	366	5.55 P.M.
		WHB	366	10.30 A.M. and 3.00 P.M.
La Crosse,	Wis.	WABN	244	9.00 A.M. and 1.30 P.M.
Lafayette,	Ind.	WBAA	273	9.50 A.M.
Lancaster,	Pa.	WDBC	258	11.45 A.M.
Lansing,	Mich.	WKAR	285	12.00 noon.
		WREO	285	9.00 P.M.
Lincoln,	Neb.	WCAJ	275	10.30 A.M.
		WFAV	275	11.00 A.M.
Lockport,	N. Y.	WMAK	466	11.00 A.M.
Los Angeles,	Cal.	KFI	467	5.30 P.M.
		KHJ	404	12.30 P.M. and 8.00 P.M.
Louisville,	Ky.	WHAS	400	4.50 P.M.
Madison,	Wis.	WHA	535	12.00 noon.

City	*State*	*Station*	*Wavelength*	*Time of Broadcasting*
Manhattan,	Kans.	KSAC	341	12.00 noon.
Memphis,	Tenn.	WMC	500	10.30 A.M. and 9.30 P.M.
Milwaukee,	Wis.	WCAY	266	10.15 A.M.
		WHAD	275	11.00 A.M.
Minneapolis,	Minn.	WCCO	416	10.30 A.M. and 10.00 P.M.
Mobile,	Ala.	WEAP	263	12.00 noon.
Moorhead,	Minn.	WPAU	258	11.00 A.M.
New York,	N. Y.	WAHG	316	12.00 noon and 10.45 P.M.
		WEAF	492	12.00 noon.
		WHN	361	10.30 A.M. and 11.00 P.M.
		WNYC	526	10.30 P.M.
		WJZ	454	10.00 P.M.
Norfolk,	Neb.	WJAG	270	12.15 P.M.
Norfolk,	Va.	WTAR	261	6.00 P.M.
Norman,	Okla.	WNAD	254	2.00 P.M. and 9.15 P.M.
Oakland	Cal.	KGO	299	1.30 P.M. and 6.45 P.M.
		KLX	510	7.15 P.M.
Orange	Tex.	KFGX	250	11.45 A.M.
Omaha,	Neb.	WIAK	278	10.20 A.M. and 1.30 P.M.
		WOAW	526	10.00 P.M.
Osseo,	Wis.	WTAQ	254	12.15 P.M.
Peoria,	Ill.	WJAN	273	10.30 A.M.
Philadelphia,	Pa.	WIP	508	1.30 P.M. and 6.00 P.M.
		WOO	508	11.30 A.M. and 10.00 P.M.
Phoenix,	Ariz.	KFAD	360	5.30 P.M.
Pittsburgh,	Pa.	KDKA	309	12.30 P.M. and 10.00 P.M.
Portland,	Ore.	KFEC	248	12.00 noon and 6.00 P.M.
		KGW	485	11.30 A.M. and 7.30 P.M.
Providence,	R. I.	WEAN	270	11.10 A.M. and 5.40 P.M.
		WJAR	306	12.00 noon and 4.00 P.M.
Raleigh,	N. C.	WFBQ	252	12.30 P.M. and 3.00 P.M.
Rapid City,	S. D.	WCAT	240	10.30 A.M. and 1.30 P.M.
Rochester,	N. Y.	WHAM	278	2.55 P.M.
Saginaw,	Mich.	WABM	261	9.15 A.M. and 5.00 P.M.
St. Louis,	Mo.	WEW	248	11.00 A.M.
		KSD	545	10.00 A.M. and 10.00 P.M.
Salt Lake City,	Utah	KDYL	306	7.00 P.M.
San Antonio,	Tex.	WOAI	395	10.30 A.M. and 12.15 P.M.
San Juan,	P. R.	WKAQ	341	9.00 A.M. and 9.00 P.M.
Schenectady,	N. Y.	WGY	380	11.45 A.M.
Scranton,	Pa.	WQAN	250	12.30 P.M. and 4.00 P.M.
Seattle,	Wash.	KFOA	450	8.15 P.M.
		KFQX	233	7.00 P.M.
		KJR	384	7.30 P.M.
Shenandoah,	Ia.	KFNF	266	12.00 noon and 9.45 P.M.
Sioux City,	Ia.	WEAU	275	10.15 A.M.
Syracuse,	N. Y.	WFBL	252	1.00 P.M.
Springfield,	Mass.	WBZ	331	10.00 P.M.
State College,	N. M.	KOB	349	11.55 A.M. and 9.45 P.M.
Stevens Point,	Wis.	WLBL	278	9.45 A.M. and 12.30 P.M.
Storrs,	Conn.	WABL	275	12.00 noon.
Tampa,	Fla.	WDAE	273	5.00 P.M.
Trenton,	N. J.	WOAX	240	11.00 A.M. and 12.15 P.M.
Washington,	D. C.	NAA	435	10.05 A.M. and 10.05 P.M.
		WRC	469	10.00 P.M.
Wichita,	Kans.	WEAH	268	10.40 A.M.
Yankton,	S. D.	WNAX	244	10.00 A.M.

Building Sets Is Popular in Holland

Most radio fans in Holland prefer to build their own sets, according to recent reports from Amsterdam and consequently few purchasers of complete sets are to be found in the Netherlands. Dutch amateurs prefer the "three honeycomb-coil system," few using variometers or variocouplers. The Dutch have licensed six broadcasters; a tax of 100 florins a year is levied for an hour a week of broadcasting. The Government itself, however, plans to erect a station, but listeners in of the Netherlands may still listen to radio concerts from British, German, French, Belgian and Swiss stations. The recent formation of a dealers association is expected to aid in popularizing radio in Holland.

Permits to Buy Sets

Polish radio regulations are reported to be so severe and complex that dealers are required to demand official permits of customers before they can sell complete receiving sets or loudspeakers. Despite the regulations and a sales tax of 20 percent on imported apparatus, radio has become a craze in Poland. Receiving set licenses are granted to only citizens of age, and fees are levied upon listeners by the government and by the broadcasters.

* * *

Anti-antenna Ordinance

Because of the various objections raised against antennas on roofs by Berlin chimney sweeps, a city ordinance has been passed to the effect that all radio equipment over roofs within the city limits must come down.

WHAT'S NEW IN RADIO APPARATUS

This department is conducted by **Popular Radio Laboratory** *for the purpose of keeping the radio experimenter and the broadcast listener informed concerning the newest inventions and the approved developments in radio equipment. Only such apparatus as has been tested and endorsed by the Laboratory is noted in these columns.*

AERIALS

Spring aerial and counterpoise; Mack Co.

AUDIO-FREQUENCY TRANSFORMERS

"Marle" audio-frequency transformer; Marle Engineering Co.

"Mar-Co" audio-transformer; Martin-Copeland Co.

Maxum" audio-frequency transformers; Maxum Radio & Electric Co.

"Se-Ar-De" amplifying transformer; R. Mitchell Co.

Audio-frequency transformer; Modern Electric Mfg. Co.

Push-pull transformers; Modern Electric Mfg. Co.

"National" audio-frequency transformer; National Transformer Mfg. Co.

Audio-frequency transformer; New York Coil Co.

BATTERIES

"Red Seal" dry batteries; Manhattan Electrical Supply Co.

"Eveready" storage "A" batteries; National Carbon Co., Inc.

"Eveready" dry-cell "A" "B" and "C" batteries; National Carbon Co., Inc.

"Novo" "B" batteries; Novo Mfg. Co.

"B" BATTERY ELIMINATORS

Mayolian B-Supply; Mayolian Radio Mfg. Co.

Mayolian A.C. transformer unit (for eliminator); Mayolian Radio Mfg. Co.

Mayolian D.C. filter unit (for eliminator); Mayolian Radio Mfg. Co.

BINDING POSTS

"Read 'em" binding posts; Marshall-Gerken Co.

CRYSTAL DETECTORS

"DX-Alena" crystal; G. Everett Marsh, Inc.

Miller-B-Metal crystal; A. H. Miller Radio Co.

Miller-B-Metal battery crystal; A. H. Miller Radio Co.

Miller-B-Metal fixed detector; A. H. Miller Radio Co.

Argentite crystal; Mineral Products Co.

"M.P.M." crystal; M. P. M. Sales Co.

"Arlington" NAA crystal detector; Newman-Stern Co.

NAA meter tested crystal; Newman-Stern Co.

DIALS

Knobs and dials; R. Mitchell Co.

4" "Accuratune" dial; Mydar Radio Corp.

"Accuratune" micrometer control; Mydar Radio Corp.

FIXED CONDENSERS

Fixed condenser; New York Coil Co.

GRID-LEAKS AND RESISTANCES

"Mar-Co" resisto coupler; Martin-Copeland Co.

"Mar-Co" variable grid-leak; Martin-Copeland Co.

Resistance mountings; Leslie F. Muter Co.

A FIXED CARBORUNDUM CRYSTAL

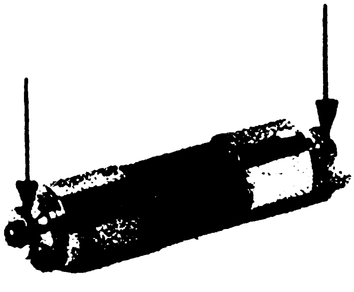
Name of instrument: Crystal detector.

Description: This instrument contains a carborundum crystal in permanent adjustment. The crystals themselves are mounted inside the glass cylinder with two brass caps holding the terminals at either end. The terminals are brought out to binding posts with a thumbnut on each terminal for fastening in the circuit of the receiving set.

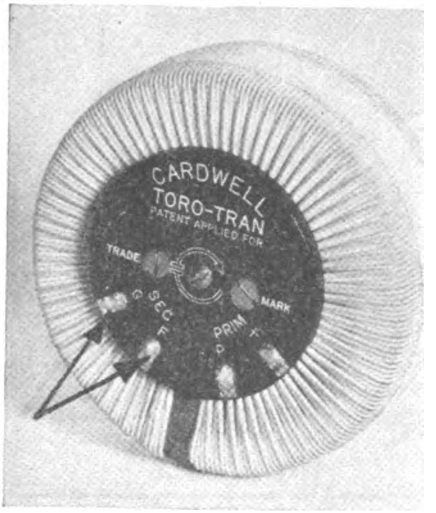
Usage: In any receiver that employs a crystal detector for rectification.

Outstanding features: Compact. Needs no adjustment. Long life.

Maker: The Carborundum Co.



A detector that needs no adjustment.



A toroid coil equipped with soldering lug terminals

A NOVEL RADIO-FREQUENCY TRANSFORMER

Name of instrument: Radio-frequency transformer.

Description: This transformer is wound in a semi-toroid form and consists of two windings, primary and secondary, connected in the plate circuit of one tube and the grid circuit of the following tube respectively. The turns are wound so that the outer edge of the turns is in a single layer and the sides and the inner edges are shifted regularly out of place, one above and one below the adjacent turns. This construction of winding gives a rigid winding and at the same time limits the external magnetic field to the smallest physical dimensions.

Usage: In a radio-frequency circuit as an inter-stage coupling unit.

Outstanding features: Toroid shape. Low external fields. Neat appearance.

Maker: Allen D. Cardwell Mfg. Corp.

Resistances; Leslie F. Muter Co.
Mc-Am-Co grid-leak; Michigan Elec. & Mfg. Co.
Variable grid-leak; New York Coil Co.

HEADPHONES

"Red Seal" headset; Manhattan Electrical Supply Co.
"Repeater" phones; Moss-Schury Mfg. Co.
"Mozart-Radioceive" headset; Mozart-Grand Co.
"Murdock" phones; Wm. J. Murdock Co.
"Red-Head" phones; Newman-Stern Co.

INSULATORS

Antenna-lead-in insulator; Leslie F. Muter Co.
Bakelite hot-moulded insulator; W. G. Nagel Electric Co.

JACKS

"Mar-Co" shur-grip jacks; Martin-Copeland Co.
Non-solder jack; Metro Electric Mfg. Co.
Jack; Wm. J. Murdock Co.

KITS

8-tube Superheterodyne kit; Moskowitz & Herbach.
"National" Regenaformer kit; National Co., Inc.
Kit for Roberts' circuit; J. Nazeley Co.
Superheterodyne kit; New York Coil Co.

LIGHTNING ARRESTERS

Guardian Arrester; Leslie F. Muter Co.
Lightning Arrester No. 200; Leslie F. Muter Co.

LOOPS

"Red Seal" Map-loop; Manhattan Electrical Supply Co.
"Marion" folding loop aerial (with compass); Marion Electrical Mfg. Co.
Suportena folding loop; J. Nazeley Co.
Portena folding loop; J. Nazeley Co.

LOUDSPEAKERS

"Magnavox" reproducers; Magnavox Co.
"Manhattan" loudspeaker; Manhattan Electrical Supply Co.
"Morrison" loudspeaker; Morrison Laboratories, Inc.
"Mozart" loudspeaker; Mozart-Grand Co.
"Atlas" loudspeaker; Multiple Electric Products Co., Inc.
"Murdock" loudspeaker; Wm. J. Murdock Co.
"Music Master" loudspeaker; Music Master Corp.
"National" Dual amplifiers; National Transformer Mfg. Co.

MISCELLANEOUS ACCESSORIES

"Malone-Lemmon" Control-o-meter; Malone-Lemmon Products.
Points: Marshall-Gerken Co.
"Switch" lever; Marshall-Gerken Co.
"Mar-Co" multi-connector; Martin-Copeland Co.
"Bull Dog" mast seat; Mast Seat Mfg. Co.
"Mitchell" battery connector; R. Mitchell Co.
"Mitchell" antenna tensionator; R. Mitchell Co.
Mounting plates; R. Mitchell Co.
Brackets: R. Mitchell Co.
Moon radio log; Moon Radio Corp.
Morrison toner; Morrison Laboratories, Inc.
"Mu-Rad" B-Radicator; Mu-Rad Laboratories, Inc.

A HANDY WIRE CUTTER

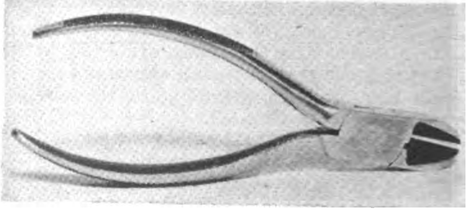
Name of instrument: Cutting pliers.

Description: A well-made hand instrument for cutting wires made of very fine quality steel with smooth running bearing and convenient hand grip. There are no rough edges on the tool to irritate the hands.

Usage: In the laboratory or workshop for cutting wire in constructing or installing radio apparatus.

Outstanding features: Handy size. Good permanent cutting edges. Smooth action. Smooth finish. Light weight.

Maker: Winchester Repeating Arms Co.



Cutting pliers that are useful in wiring up a set

A SUBSTANTIALLY CONSTRUCTED SOCKET

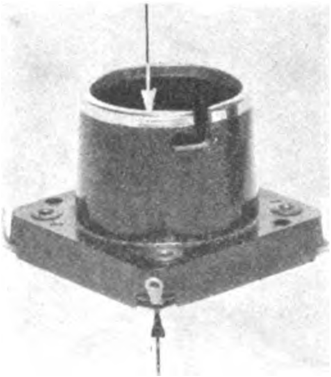
Name of instrument: Vacuum-tube Socket.

Description: A socket for standard tubes constructed completely of bakelite with four connection fingers of phosphor bronze and terminals, including in one piece the fingers and soldering lugs. The top of the socket is held in a small circular flange of nickel plated brass which prevents the edge from breaking out.

Usage: For mounting standard makes of vacuum tubes.

Outstanding features: High conductivity. Good contact. Neat appearance. Compact.

Maker: Walbert Mfg. Co.



Equipped with reinforcing metal band and soldering lugs.

"Mu-Rad" Recto-Filter; Mu-Rad Laboratories, Inc.
Instant Adjustable Ground clamp; Leslie F. Muter Co.
All-Radion products; New York Hard Rubber Turning Co.
Bakelite form for spider-web coil; J. Nazeley Co.
2-stage R. F. amplifier; Norden-Hauck, Inc.

PANELS

Panel; Marshall-Gerken Co.

PHONE PLUGS

"Mar-Co" switch plug; Martin-Copeland Co.
"Mar-Co" multi-plug; Martin-Copeland Co.
Automatic shock-proof phone plug; Leslie F. Muter Co.

PHONOGRAPH ATTACHMENTS

"Red Seal" phonograph attachment; Manhattan Electrical Supply Co.
Phonograph attachment; Morrison Laboratories, Inc.
"Atlas" phonograph attachment; Multiple Electric Products Co., Inc.
"Accuratune" phonograph attachment; Mydar Radio Corp.

POTENTIOMETERS

Armorclad potentiometer; Martin-Copeland Co.

POWER AMPLIFIERS

"Magnavox" power amplifiers; Magnavox Co.

RADIO CABINETS

Solid mahogany cabinet; Nassau Cabinet Co.

RADIO-FREQUENCY TRANSFORMERS

"Marle" radio-frequency transformer; Marle Engineering Co.
"Maxum" radio-frequency transformer; Maxum Radio & Electric Co.
Reflex transformer; Modern Electric Mfg. Co.
Superformer; Moskowitz & Herbach.
"National" radio-frequency transformer; National Transformer Mfg. Co.
Radio-frequency transformer; New York Coil Co.
Intermediate-frequency transformer; New York Coil Co.
Self-balanced R.F. transformer; Nolte Mfg. Co.

RECEIVING SETS

"Magnavox" broadcast receivers; Magnavox Co.
"Magnavox" combination sets; Magnavox Co.
"Marshall" receivers; Marshall Radio Products, Inc.
"Marwol" A1 receiver; Marwol Radio Corp.
"Mercury" receiver; Mercury Radio Products Co.
Metrodyne Super-five receiver; Metro Electric Co.
"Michigan" receiver; Michigan Radio Corp.
"Miraco" receiver; Midwest Radio Corp.
Miller-B-Metal crystal set; A. H. Miller Radio Co.
Mohawk 5-tube receiver; Mohawk Electric Corp.
"Moon" "Satterlee antennaless" receiver; Moon Radio Corp.
"Moon" Ultra-Five receiver; Moon Radio Corp.
"Mozart" Baby Grand; Mozart-Grand Co.
"Mu-Rad" receiver; Mu-Rad Laboratories, Inc.
"Murdock" neutrodyne receiver; Wm. J. Murdock Co.
"Somerset" receiver; National Air-Phone Corp.
C-10 Navy Model Superheterodyne; Norden-Hauck, Inc.
Improved regenerative superheterodyne receiver; Norden-Hauck, Inc.
Standard loop superheterodyne receiver; Norden-Hauck, Inc.
Superheterodyne C-7 (experimenters); Norden-Hauck, Inc.

RHEOSTATS

Marshall-stat; Marshall Electric Co.
Rheostat; Marshall-Gerken Co.
"Mar-Co" rheostat; Martin-Copeland Co.

A NEW GLASS INSULATOR

Name of instrument: Antenna insulator.

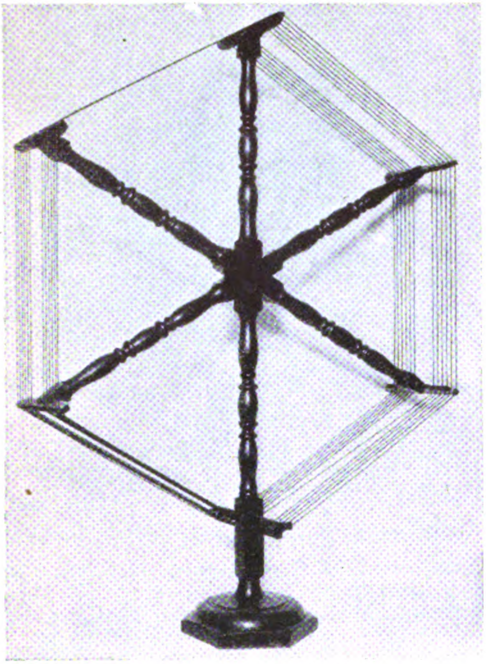
Description: This insulator is constructed entirely of a single piece of glass moulded into a form that includes four thin flanges and a larger center flange. The insulator is strong and its construction limits leakage to a low value even in bad weather.

Usage: For insulating outdoor antenna wires.

Outstanding features: Compact. Light weight. Strong.

Maker: M. M. Fleron & Son, Inc.

A glass insulator molded in a single piece.



This loop more nearly approaches the cylindrical coil shape than the square type.

SOCKETS AND ADAPTERS

"Thorobred" socket; Marshall-Gerken Co.
"Mar-Co" sockets; Martin-Copeland Co.
Double contact tube socket; Mazda Radio Mfg. Co.
Antenna adapter for standard loop superheterodyne receiver; Norden-Hauck, Inc.

SWITCHES

"Mar-Co" switches; Martin-Copeland Co.
Keelock switch; Metro Electric Mfg. Co.
"Se-Ar-De" automatic selector switch; R. Mitchell Co.
"Mac-kontrol"; Mack Company.
Switches; Leslie F. Muter Co.

TESTING INSTRUMENTS

Radiometer; R. Mitchell Co.
Dry cell tester; W. G. Nagel Electric Co.
Ammeter; W. G. Nagel Electric Co.
High resistance voltmeters and voltammeters, W. G. Nagel Electric Co.

A HEXAGON SHAPED LOOP

Name of instrument: Loop antenna.
Description: A collapsible loop antenna that is supplied for final assembly by the experimenter. It contains three turned wooden arms which fit together and a special wooden base. The amateur winds the wire on the loop and connects it to the two binding post terminals that are furnished.
Usage: As an antenna pick-up device for multitube receivers.
Outstanding features: Well finished appearance. Good directional selectiveness. Easy to set up. Good appearance.
Maker: R. B. Scribner Co.

TUBES

"Magnavox" vacuum tube; Magnavox Co.
A-C radio tube; McCullough Sales Co.
"Myers" tube; E. B. Myers Co., Ltd.
Eveready vacuum tube, type 201-a; Herman A. Nussbaum Sales Co.
"Nutron" solodyne tube; Nutron Mfg. Co.
Matched tube; Nutron Mfg. Co.

TUNING INDUCTANCE UNITS

180-degree variocoupler; Manhattan Electrical Supply Co.
Control-o-meter; Malone-Lemmon Products.
Variometers; Marshall-Gerken Co.
"Mar-Co" tuner; Martin-Copeland Co.
"Cockaday" coils; McConnell Cable & Specialty Co.
"Se-Ar-De" coupler; R. Mitchell Co.
"Precision" selector; Moskowitz & Herbach.
Roberts units; J. Nazeley Co.
Oscillator coupler; New York Coil Co.
Journal filter tuner coils; Nolte Mfg Co.
Journal one knob set coil; Nolte Mfg. Co.
Wave trap filter coil; Nolte Mfg. Co.

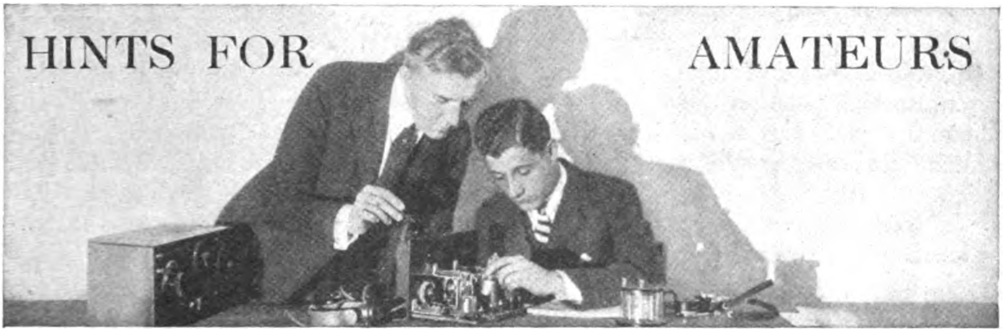
VARIABLE CONDENSERS

"Red Seal" variable condensers; Manhattan Electrical Supply Co.
"Mar-Co" super-vernier condenser; Martin-Copeland Co.
"Mar-Co" neutralizing condensers; Martin-Copeland Co.
Variable condenser; Mignon Electric Mfg. Corp.
"Se-Ar-De" condenser; R. Mitchell Co.
"National" condenser; National Co., Inc.
Grounded variable low-loss condenser; New York Coil Co.
Selector variable condenser; with self-balanced coils attached; New York Coil Co.
"Niagara" Mignon condenser; Niagara Sales Corp.

The Government Should not Censor the Ether

"THE character of the matter sent out must be left to the stations themselves and they, in turn, must be governed by the wishes of their listeners. The public will unquestionably turn to the station from which it gets the most worthwhile material, and, in any event, interference by the Government in the character of programs would inevitably mean censorship. It would become the negation of the fundamentals of free speech and free dissemination of information."

—HERBERT HOOVER
U. S. Secretary of Commerce



HINTS FOR AMATEURS

Conducted by Albert G. Craig

"B" Battery Eliminators

There are now on the market a number of devices for furnishing plate current to radio receiving sets from the alternating-current and direct-current lighting lines. A "B" battery eliminator for direct current needs no rectifier. All that is necessary is some form of resistance device to bring the voltage down to a value suitable for use on the detector and amplifying tubes. In addition to this is necessary a filter circuit designed to eliminate any voltage variations in the supply current so that no hum will be discerned when the set which uses such a supply is connected to the telephones or loudspeaker. In some of these devices an electrolytic rectifier is used and in some a vacuum-tube rectifier is used. Some devices rectify both halves of the cycle and some of them only rectify a half wave. The full-wave rectifier is desirable. The rectifiers that use standard UV-201-a tubes should never be overloaded. In other words, if a multi-tube set is attached to such a device employing, say, two UV-201-a tubes, the current drawn through these tubes as rectifiers may be too great for the normal filament emission and this will cause the tube to deteriorate rapidly. It is, therefore, imperative when using rectifiers of this type with this type of tube, that a set should contain not more than five tubes and it should be equipped with "C" batteries to limit the total plate energy required for operation in order to make the tubes last a suitable length of time.

If this is not done the filament emission of the tubes will fall off rapidly and they will be worthless in about 250 or 300 hours of operation. This is usually a serious trouble experienced when the uninitiated radio set user tries to operate a multi-tube set on such a device.

Be sure that you limit the total plate current in your receiver with "C" batteries properly arranged so that you do not overload the tubes in the "B" eliminator no matter what design it may be and then you will get proper results from the eliminator itself.

Straight-line-frequency Condensers

There is a great call at the present time for so-called straight-line-frequency condensers although there is not at the present time (and never will be) any such instrument. This is because it is impossible to make a variable condenser that will have a straight-line-frequency characteristic with all types of coils used in radio. The ultimate reason for this is that all coils used in radio have some distributed capacity varying from a relatively small amount to quite a large value and this fixed shunt capacity across the variable condenser shifts the capacity across the circuit and throws out the frequency curve from a straight-line characteristic. Therefore, even a condenser especially designed for use with a theoretically perfect coil with zero distributed capacity would not give a straight-line-frequency curve with any type of coil now on the market. Any specific condenser which claims to be a straight-line-frequency condenser is so only with *one specific type of coil* for which the condenser has been designed to operate in conjunction with. In other words, manufacturers will find that they will have to design a coil to go with their straight-line condensers in order to be able to substantiate their claim that their condenser is a straight-line-frequency condenser and this same condenser, when used with a coil of different distributed capacity, will show a curve for the frequency characteristic instead of a perfectly straight-line. When buying such a condenser be sure that you also obtain the coil that the condenser was calculated to operate with, if you desire an absolutely straight-line characteristic.

The Application of Simplified Control to Tuned Radio-frequency Receivers

Eliminating one or two dials from the ordinary triple control tuned radio-frequency receiver can be accomplished by employing some of the double or triple unit variable condensers now on the market. The use of this simplified unit will enable much quicker and more accurate setting of the dial with a considerable improvement in the results obtained from the receiver. A multi-unit condenser to be employed satisfactorily should have matched units, that is, all of the separate capacity units should be so fixed on the shaft that the capacity of all three will be the same (or practically so) for any setting of the main dial. This is important when a triple unit condenser is used for the receiver. An easier combination, and one that is probably more practical, would be the use of a single condenser for tuning of the antenna circuit and a double unit for tuning simultaneously the two succeeding circuits. Be sure to obtain a multi-unit condenser of this type that is matched within at least five percent variation.

One Stage of Radio-frequency

The addition of a single radio-frequency tube to an ordinary receiver or one of the regenerative type will enable the user to tune considerably sharper with his present set and at the same time to increase his distance range.

Particularly is this single tube an improvement when used with a closely coupled regenerative receiver. Its function in this case would also include the prevention of radiation by the regenerative receiver. This is especially true if the single stage of radio-frequency amplification is neutralized by one of several closely allied methods of the bridge principle.

The Application of Varnish to Radio Coils

In general, the use by the amateur of varnish or shellac in coils should be avoided. This is because the amateur or radio fan seldom has access to the right kind of varnish or knows how to apply it.

Certain forms of high-grade varnish have been found (when applied in extremely thin coats) to increase the distributed capacity of a coil only slightly, and the losses incurred through this increase have been found to be less than the losses due to leakage through the coil when left dry in a humid atmosphere.

In some cases using a varnish of the right kind the over-all resistance at radio frequencies has been unexpectedly found to be reduced by the application.

Engineering
Library
AUG 27 1925
P831

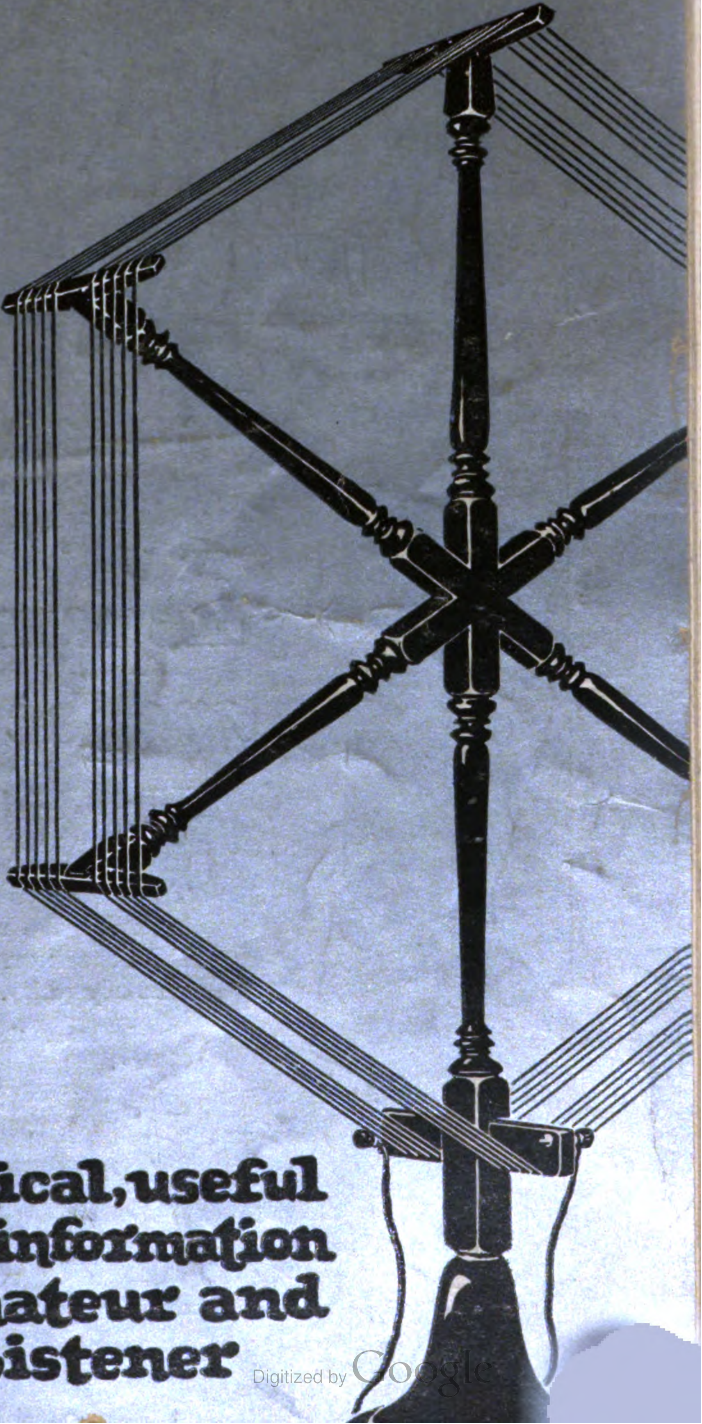
Popular Radio

with which is combined The Wireless Age

Edited by **KENDALL BANNING**

25¢

EPTEMBER
1925



Containing

**00 pages of practical, useful
nd authoritative information
or the Radio Amateur and
he Broadcast Listener**

It's a *genuine* UV-201-A only when it bears the name Radiotron *and* the RCA mark

RADIOTRON
UV-201-A
LICENSED ONLY TO EXTENT INDICATED ON CARTON

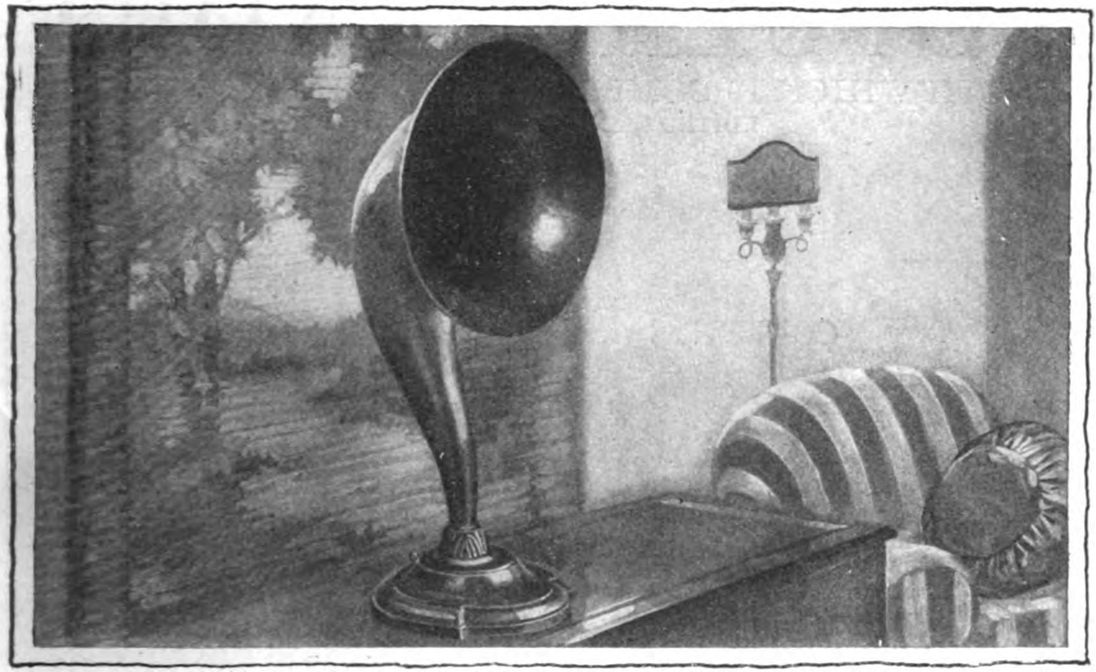
WD-11, WD-12, UV-199, UV-200, and UV-201-A are the type names of Radiotrons. They belong to Radiotrons only. To be sure you are buying the genuine, look for the name Radiotron and the RCA mark on the base. Then you are sure of quality.

Radio Corporation of America
Chicago New York San Francisco

RCA Radiotron

REG. U.S. PAT. OFF.

AN RCA PRODUCT



The Brandes Speaker—Type H—a simple, attractive quality horn with a smart antique finish. Adjustable. **$18.**

Acoustics by Brandes

ACOUSTICS is the science of sound. Radio acoustics is the science of transforming electrical impulses into audible sound—the new and absorbing study of *real* reproduction of voice and music. And in this field Brandes have been pioneers since 1908.

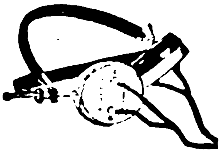
Today, along with an era of remarkable new speakers by Brandes, has dawned an epoch of Brandes acoustics built into better radio sets.

So, whether you buy a set *and* a speaker or a set with a self-contained speaker, insist on "Acoustics by Brandes" and be assured of finest tone quality and uniformly good reproduction.

Brandes—*experts in radio acoustics since* 1908

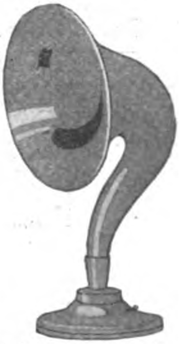
Brandes Cabinet Speaker of mahogany in the popular brown finish. Same tone quality and volume as Type H Speaker. Adjustable. . . . . . . **$30.**

The Superior Matched Tone Headset to tune in with. To listen undisturbed—and undisturbing. . . . . . **$4.50.**



The new phonograph attachment—same unit as Type H Speaker. Adjustable. . . . . . . **$10.**

The Brandes adjustable Table-Talker with the gooseneck horn. **$10.**



© Copyrighted by Brandes Products Corporation, 1925.

Prices slightly more west of the Rockies and in Canada.

POPULAR RADIO

WITH WHICH IS COMBINED "THE WIRELESS AGE"

EDITED *by* KENDALL BANNING

FOUNDED 1911

CONTENTS *for* SEPTEMBER, 1925

(Cover design by Frank B. Masters)

VOLUME VIII NUMBER 3

The Man Who First Found a Use for Ionization in Radio..........FRONTISPIECE
How the Air Affects Radio........................*E. E. Free*.........*Page* 199
How Radio Dead-spots are Found by a Wandering Broadcasting Station........................*J. O. Perrine*........... 207
When You Turn Your Dials........................*Jacques Avon*........... 212
Men Who Made Radio... 218
9th Installment
Useful Charts for Amateurs........................*C. C. Todd, Jr.*.......... 221
Simple "How-to-Build" Articles for Beginners.....*Laurence M. Cockaday*... 227
No. 11: An Audio-frequency Amplifier for AC Tubes
The Atom..*William Bragg*......... 232
Article No. 2: The Nature of Gases
The Diary of a Radio Fan........................*D. R. Patterson*........ 237
Handy Tools for Radio Fans.. 239
No. 6: The Jackknife
"What Set Shall I Buy?"........................*The Technical Staff*..... 240
4th Installment
How to Get the Most Out of Your Ready-made Receiver........................*S. Gordon Taylor*....... 244
No. 8: The Freed-Eisemann Neutrodyne
Call Letters That Have a Past....................*Lawrence A. Corridon*... 255
Riding to Riches by Radio........................*Ralph E. Renaud*....... 256
Part II
Listening Horns to Detect Aircraft.. 261

DEPARTMENTS

In the Experimenter's Laboratory..............*The Technical Staff*..... 262
The Broadcast Listener........................*Raymond Francis Yates*.. 272
What's New in Radio Apparatus................*The Technical Staff*..... 276
In the World's Laboratories....................*E. E. Free*............. 280
What Readers Ask.............................*Laurence M. Cockaday*... 288
Broadcasts...................................*J. Andrew White*....... 294

VOLUME VIII SEPTEMBER, 1925 NUMBER 3

Published monthly by Popular Radio, Inc., 627 West 43rd St., New York, N. Y., telephone number, Chickering 1906; Douglas H. Cooke, President and Treasurer; Kendall Banning, Vice-President; Laurence M. Cockaday, Secretary; Joseph T. Cooney, Asst. Treasurer. Price 25 cents a copy; subscription $3.00 a year in the U. S., Canada and all countries within the domestic postal zone; elsewhere $3.50 a year, payable in advance. The International News Company, Ltd., No. 5 Bream's Bldg., London, E. C. 4, sole distributors in England. Entered as second class matter April 7, 1922, at the Post Office at New York, N. Y., under the act of March 3, 1879. Copyright, 1925, and title registered as a trade-mark by Popular Radio, Inc. Copyright in Great Britain by Popular Radio, Inc., 6 Henrietta St., Covent Garden, W. C., London, England.

Printed in U. S. A.

LAURENCE M. COCKADAY, *Technical Editor*
E. E. FREE, Ph.D., *Contributing Editor* JOHN V. L. HOGAN, *Contributing Editor*

For advertising rates address
E. R. CROWE & COMPANY, INC.
New York: 25 Vanderbilt Avenue Chicago: 225 North Michigan Avenue

The Progressive Policy of POPULAR RADIO is Serving the Interests of Science

"POPULAR RADIO, *one of the first magazines in the broadcast field, has kept abreast of the extremely rapid development of this science in a manner that reflects much credit upon its editorial direction. The progressive policy of this magazine in giving publicity to developments in the radio field which will affect the future of the science is particularly commendable.*"

H. P. Davis

VICE-PRESIDENT, WESTINGHOUSE
ELECTRIC & MANUFACTURING COMPANY

Courtesy of Mr. H. P. Donlé

The Man Who First Found a Use for Ionization in Radio

THE *sodion detector tube, invented by Harold P. Donlé, operates by virtue of a swarm of ionized atoms which it contains. Other ionized atoms, formed from the gases of the air, are now believed to be of great importance in the transmission of radio waves through the upper levels of the atmosphere.*

Popular Radio

WITH WHICH IS COMBINED "THE WIRELESS AGE"

VOLUME VIII SEPTEMBER, 1925 NUMBER 3

How the Air Affects Radio

Theories of the transmission of radio waves have created much argument among radio engineers. Controversies over the Heaviside Layer are still fresh in everyone's memory. During the past twelve months some new theories of great interest have been formulated; among the important factors are the atoms and electrons of the air and the magnetic field of the earth.

By E. E. FREE

IF a fish at the bottom of the sea knew how to build himself a radio transmitter we might expect his broadcasts to be hampered somewhat by the fact that above and around his apparatus there lay a vast ocean of salty water through which radio waves could not be expected to move with complete freedom. Indeed, we know from the experience of the man-made fishes which we call submarines that the ocean of water really does hamper the progress of radio waves.

We forget, however, that all our ordinary broadcasting takes place at the very bottom of another great ocean; the ocean of air that surrounds the earth and in the depths of which we live. The radio waves with which we work do not move in a vacuum or in pure ether. They move in the air. "On the air" and "on the ether" are used popularly as synonymous terms. "Through the air" and "by means of the ether" would be more exact, but, in any case, the air gets into it.

Does this air through which we *must* do our broadcasting affect radio in any way? A year ago most engineers would probably have answered no, except as the upper levels of the atmosphere became involved in the supposed phenomena of the Heaviside Layer.

Now we are far less sure. It appears that the atoms and electrons of the air do have some rather important effects on the propagation of radio waves. Not only is the difference in transmission between day and night now ascribed to effects in which these atoms play a controlling part, but such things as fading, the deviation of the apparent direction of radio waves and other anomalies of transmission are now believed to be affected quite materially by things that happen to the particles of the air.

The work which has led to these ideas began with the attempt to define more exactly and surely the nature of the famous Heaviside Layer. This layer was supposed, you remember, to consist of a stratum of very thin air, high up above the earth and possessed of a considerable electric conductivity. It acted, the physicists thought, as a sort of mirror for the radio waves, forcing them to travel around the curvature of the earth instead of moving off in straight lines into space.

There were two theories of long-distance radio transmission. One was this Heaviside Layer theory. The other and opposing theory was the Gliding Wave theory. It assumed that the waves traveled along the surface of the ground in much the same way in which the waves of "wired radio" travel along the copper wire that guides them. Arguments between the advocates of these two theories were rife up until about two years ago.[*]

Gradually it became apparent that both of these theories might be right. A radio wave moving outward from a transmitting antenna seems to be split into at least two parts. One of these parts moves upward into the upper levels of the atmosphere and travels along something, perhaps a Heaviside Layer, which exists there to provide a path for the waves. The other part of the wave moves outward along the surface of the ground (or of the water) just as the Gliding Wave theory assumed that it did. Actual experiments carried out in England on December 11, 1924, and repeated on February 17, 1925, resulted in a virtual proof of this two-path transmission.[†] Still more convincing evidence was obtained by Mr. Greenleaf W. Pickard and his collaborators in their radio investigations during the eclipse of the sun on January 24, 1925.[‡]

This idea of two waves helped greatly in explaining some of the phenomena of fading and of daytime absorption but it still left us essentially without an understanding of what actually happened to the upper wave—the one in the supposed Heaviside Layer—or of why the two waves split off from each other and sought their different paths through space. It is in attacking these problems that we come to the effects of the atoms and electrons in the air.

As long ago as 1912 the distinguished English physicist and radio expert, Dr. W. H. Eccles, had suggested that the conductivity of the Heaviside Layer might be caused by "ions" in the upper air. An ion is a particle of matter which carries an electric charge. Most atoms are electrically neutral. But once in a while an atom may pick up an extra electron or may lose one of its own electrons. This gives it a charge; negative in one case, positive in the other. It becomes a negative or a positive *ion*.

Many of these charged ions might exist, Dr. Eccles thought, in the upper part of our atmosphere. Being charged, they might serve to carry electric currents, just as do the similar ions which exist in the solutions used in storage batteries. Thus the Heaviside Layer would be rendered conducting and would have the property of reflecting radio waves. This ionic idea lay, rather vaguely, at the bottom of most of the reasoning about the Heaviside Layer.

On October 27, 1924, Sir Joseph Larmor, one of England's greatest mathematical physicists, read before the Cambridge Philosophical Society an important contribution to radio theory. He took this vague idea of ions in the upper air and gave it precise and definite meaning. He showed just how these ions would react on the waves and how they could produce the bendings and absorptions of the waves which we know to occur.[*]

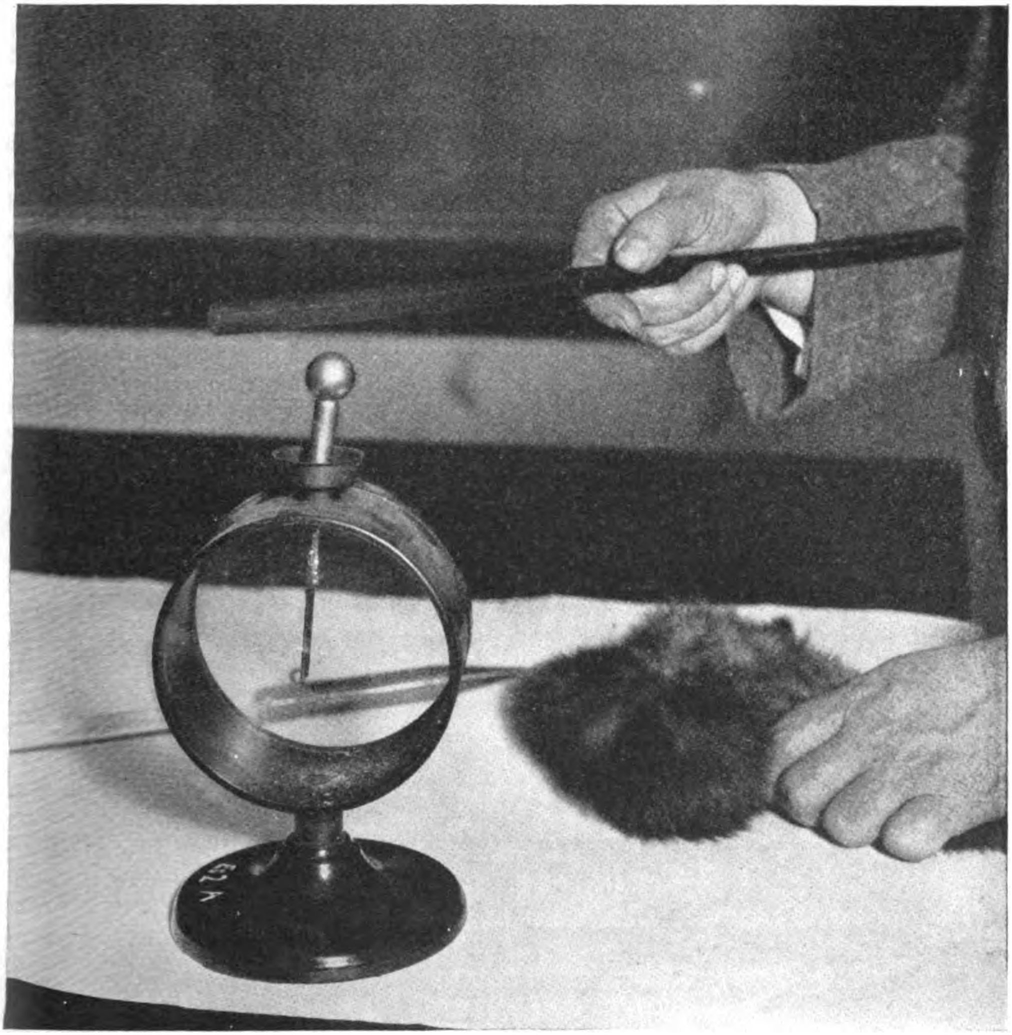
---

[*] See the papers by Dr. Elihu Thompson, Sir Oliver Lodge, General George O. Squier and Professor R. A. Fessenden in POPULAR RADIO for December, 1922, and January, March and November, 1923.

[†] "Local Reflection of Wireless Waves from the Upper Atmosphere," by E. V. Appleton and M. A. F. Barnett. *Nature* (London), vol. 115, pages 333-334 (March 7, 1925).

[‡] "The Effect of the Solar Eclipse of January 24, 1925, on Radio Reception," by Greenleaf W. Pickard. Read before the Institute of Radio Engineers, New York City, April 1, 1925. To be published in the *Proceedings* of that Institute. See also the summary note in POPULAR RADIO for July 1925, pages 85–86.

[*] Larmor's paper was published, in abstract, in *Nature* (London), vol. 114, pages 650–651 (November 1, 1924) and in full in the *Philosophical Magazine* (London), vol. 48, pages 1025–1036 (December, 1924).



Brown Brothers

A GOOD DETECTOR OF AIR IONS

The familiar gold leaf electroscope will serve very well to detect ionization in the air. The thin gold leaf, just visible to the left of the downward projection inside the glass case, stands out from the projection because it is repelled by the electric charge. In ionized air the ions rapidly carry this charge away, so that the gold leaf falls against the projection.

To see just why these ideas of ions are so important for radio theory we must examine a little more closely the nature of the air. At the surface of the earth—that is, on the bottom of the air ocean—the air has a pressure of about fourteen and one-half pounds on each square inch of surface.

A cubic foot of air weighs a little over one ounce. Approximately eighty per cent of this air, by volume, consists of nitrogen gas; approximately twenty per cent is oxygen gas. There are very small amounts of other gases; argon, carbon dioxide, hydrogen, helium, neon and others. The atoms of all these gases are relatively free. They move about rapidly in a vast cloud, like a swarm of bees.

As one goes up above the surface of the earth the air becomes thinner and thinner. At a height of seven miles, which is approximately the record for a man in an airplane, the pressure and density of the air are only about one-fourth of their values on the surface of the earth. At fifteen to twenty miles, which heights have been explored to some slight extent by means of recording instruments sent up on balloons, the density of the air is less than a twentieth of its value at the surface. At a height of fifty miles there is probably only about one one-hundred-thousandth as much air as we are accustomed to. But even up as high as three hundred miles, and possibly even higher, there are still a few scattered atoms of the various gases.

To get an idea of how the air affects radio we must think of it as a vast assemblage of individual atoms. Let us make use once more of the idea of enlargement which is so convenient in thinking about atomic dimensions.

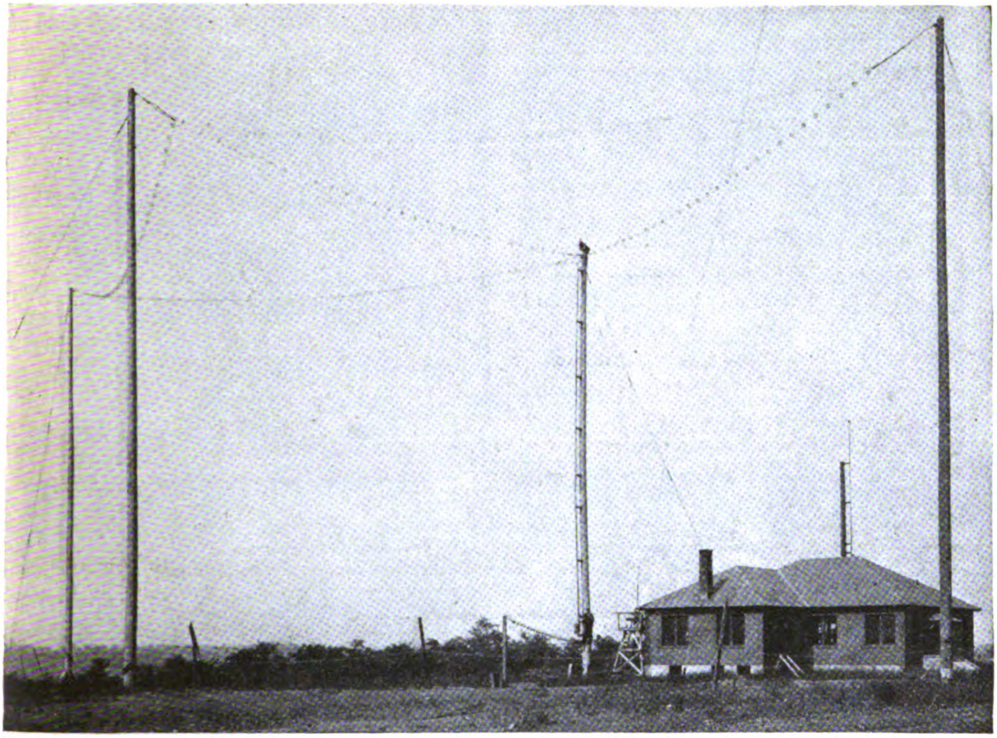
Imagine a cubic inch of air, cut out of the atmosphere somehow and contained in a small glass box. Imagine, now, that some obliging magician enlarges this small block of air for you, atoms and all, until it is a hundred million times as large as in its normal state. The glass box holding the air will now be a little more than fifteen hundred miles square. Set down on the United States it would reach from New York to Denver and from the Canadian boundary to the southern tip of Texas. Of course, it would reach up into the sky the same distance of fifteen hundred miles.

Now suppose you investigate the interior of this swollen cubic inch of air. If your eyes are quick enough you will see the rapidly moving atoms of nitrogen and oxygen and other gases in the air.

Brown Brothers

HOW IONS STOP WAVES

If a water wave entered this mass of floating logs, each log would be swung up and down by the wave. The logs would rub together and thus use up energy. This would absorb the energy of the wave. Just so, the swinging ions in the air may hit together and use up the energy of the radio waves, as is described in this article.



Westinghouse

TWO ANTENNAS FOR TESTS OF WAVE TRANSMISSION

Work with this short-wave experimental station of KDKA, near Pittsburgh, is reported to have led already to significant new data concerning the effect of atmospheric conditions on waves of different wavelengths. The horizontal cages on the tops of the masts constitute one antenna. The other one is the vertical rod visible just beyond the house.

Each of these atoms consists, you remember, of a few electrons revolving around a central nucleus, much as the planets of our solar system revolve around the sun. On the scale of enlargement which we have adopted each of these solar-system groups constituting an oxygen atom will be about one inch across. Each nitrogen atom will be a trifle larger.

All these atomic systems will be flying about inside the glass box very rapidly indeed. They collide with each other every moment. Others collide with the glass walls of the container that holds them. On the average, in our enlarged model of a cubic inch of air, the atoms will be about twenty-three feet apart. Each one will collide with another one many times a second. The average distance of travel of an atom between collisions will be about thirty-three feet.

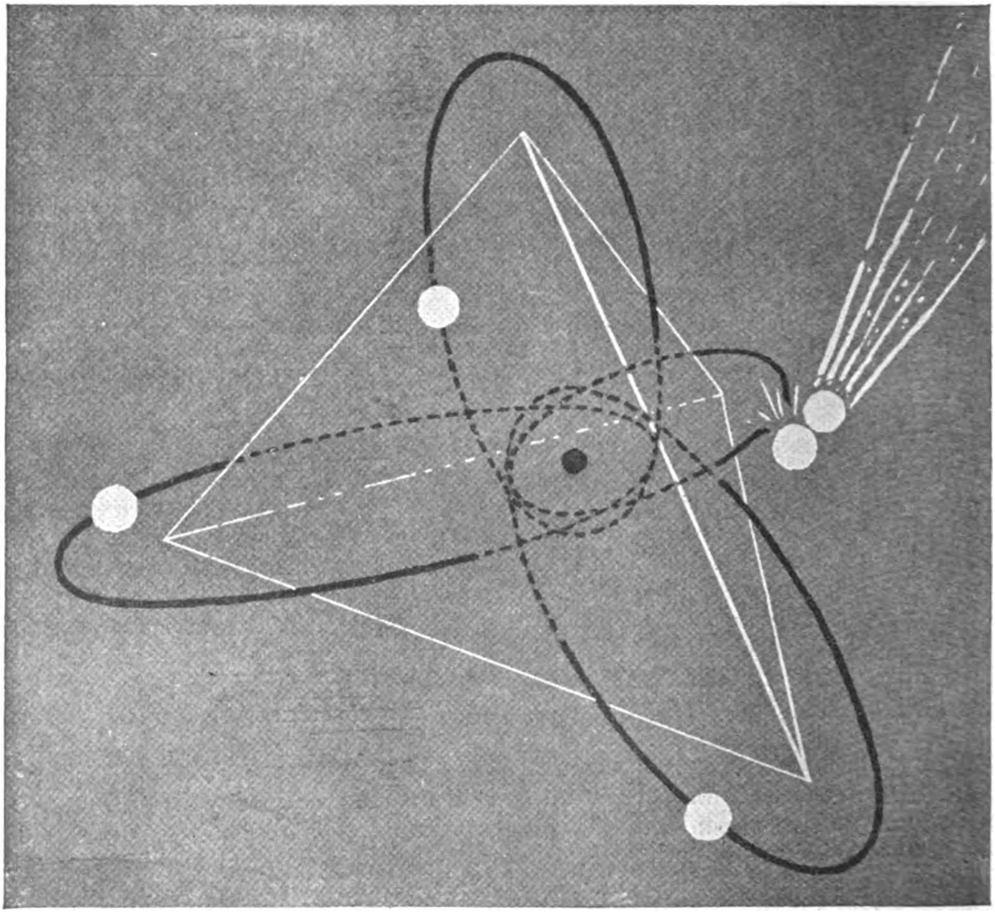
The number of atoms in even so small a bit of air is a'most incomprehensible. In ordinary air some of the atoms are attached to each other, two by two, to form what chemists call molecules. Ignoring this, and counting each such molecule only as a single atom, the number of individual particles in one cubic inch of ordinary air is expressed by the figure 440,000,000,000,000,000,000.

Imagine all of the atoms in our enlarged cubic inch of air piled up on the ground, like billiard balls. They would cover the whole United States to a depth of nearly three hundred feet. Even if the atoms were only as large as peas, there would be enough of them to cover our country up to the chin of a moderately tall man.

All this applies to a cubic inch of air at the earth's surface. As one goes up higher and higher in the atmosphere the atoms remain individually of the same size but the number of them in a cubic inch decreases greatly. At a height of fifty miles, which is about where the chief radio phenomena probably occur, the number of atoms (or molecules) in a cubic inch is probably about 1,000,000,000,000,000; still a very large number but vastly less than are present in one cubic inch of air near the ground. On the same scale of enlargement which we have been using, the one-inch atoms of this upper air would be, on the average, about two thousand feet apart instead of twenty-three feet apart. At higher levels the atoms would be scarcer still.

But our interest is not so much in the ordinary air atoms as it is in the few of them which are electrically charged or "ionized." Sir Joseph Larmor estimated that at a height of fifty miles there might be one charged atom—one "ion"—for each 100,000,000,000,000 neutral atoms. There are also a few free electrons, electrons that are flying about by themselves without being attached to atoms at all.

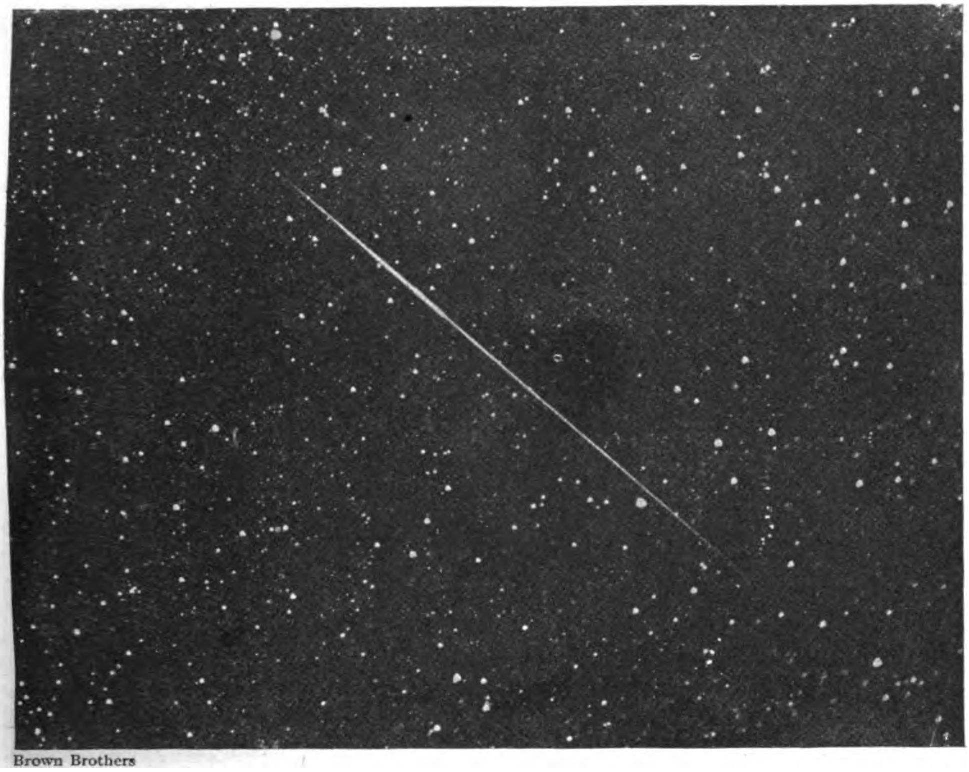
It is these charged ions and free elec-



A drawing made for **Popular Radio** by Arthur Merrick

ONE WAY TO CONVERT AN ATOM INTO AN ION

This diagram shows how a speeding electron may hit an atom of carbon and knock out one of the atomic electrons. This atom, then, minus one of its full complement of electrons, will be an ion. It will have a positive charge, the charge on the atomic nucleus being no longer neutralized in full by the outer electrons.



Brown Brothers

SHOOTING STARS TELL MUCH ABOUT THE UPPER AIR

This picture shows the track of a shooting star that happened to cross the field of the telescope while a star field was being photographed. Shooting stars are small solid bodies that encounter the earth and are heated by friction with the air. Observations of them have proved that there is still some air as high as three hundred miles above the earth.

trons which effect the radio waves.

A radio wave represents electric and magnetic force. If it hits against a charged particle, such as an ion or an electron, the wave tends to make the particle move. A single ion or a single electron is swung backward and forward by the wave in exact time with the frequency of the wave.

A five-hundred meter wave, for example, has a frequency of 600 kilocycles, which means 600,000 alternations of force each second. Such a wave will swing an ion back and forth 600,000 times a second. It is much as though a water wave on the ocean came along and swung a floating stick upward and downward in time with the successive crests and troughs of the wave.

But the important thing about this is that the swing of the ion in time with the wave may have a reaction on the wave itself. To lift and drop the floating stick on the ocean may absorb some energy. That may take away a little of the energy of the water wave. Similarly, if the ions or electrons in the air absorb some of the energy of the radio wave that may slow up the wave or deplete its energy.

There is at least one way in which this really does happen when radio waves traverse the air. This is by collision of the swinging ions with other ions or with ordinary uncharged atoms. Such collisions absorb energy. The energy must come from the thing which started the swings, namely from the radio wave. In the lower part of the air the atoms are very close together. An ion, swinging in response to a passing radio wave, is practically sure to hit many other atoms during even a single back-and-forth swing. That is why the absorption of energy from radio waves is so great in the lower part of the atmosphere. The wave is wasting its energy in bumping the swinging ions against the neutral atoms of the air.

In the upper part of the air the ions and atoms are much farther apart. When the ions swing in response to a passing wave they have a much lesser chance of hitting something and losing energy. Accordingly the loss of wave strength by such ionic absorption is much less. At a high enough level it is virtually zero.

This matter of energy absorption is but one of the effects of air particles on the wave. In the higher parts of the atmosphere, where the Heaviside Layer is supposed to be, free electrons are supposed to be even more effective than the ions. These electrons may actually assist the passage of the wave. They can make it move faster. That is one reason why the wave is bent around to follow the curvature of the earth.

Other effects of the swinging ions and electrons are due to the reaction between the particles and the magnetic field of the earth. Like all moving electric charges, an electron which is set swinging by a radio wave will be affected by any magnetic field. It is swinging in just such a field, the field due to the earth's magnetism. Two American physicists, Drs. H. W. Nichols and J. C. Schelleng, have calculated some of the effects of this terrestrial magnetic field on the vibrating electrons of the upper air and, through them, on the propagation of radio waves.* It appears that the effects are considerable; amounting, on certain probable assumptions, to a sufficient cause of fading, as well as an explanation of some of the mysterious alterations of direction which radio waves so frequently exhibit when they have travelled considerable distances. There is a probability, also, that a magnetic effect is the chief factor in dividing the original wave into the two or more parts which follow different paths.

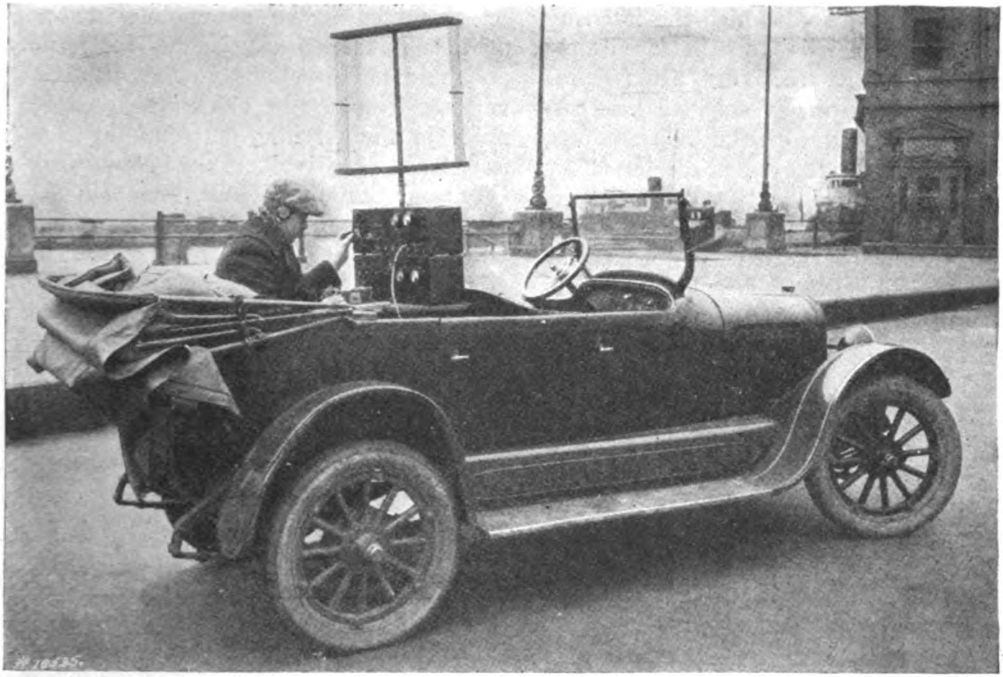
Further complexities are introduced by the fact that both the magnetic field of the earth and the number of ions in a cubic inch of air may vary from hour to hour. For example, sunlight increases the number of ions. That is probably why radio transmission is better at night than in the daytime. When these new ideas of the reactions between radio waves and the charged particles in the air shall have been worked out in detail we will be able it is already evident, to understand the day-by-day vagaries of radio much more completely than ever before.

---

*This work will be described in detail by Drs. Nichols and Schelleng in an article in an early issue of POPULAR RADIO. The mathematical theory has been set forth in "Propagation of Electric Waves Over the Earth," by Nichols and Schelleng. *Bell System Technical Journal* (New York), vol. 4, pages 215–234 (April, 1925).

The Effect of Earth Magnetism on Radio Waves

IT *is now believed that the magnetic field of the earth—the same field which keeps the magnetic compass pointing toward the North—has marked effects on the ions and electrons of the air, and through them on the propagation of radio waves. This theory has been worked out by Dr. H. W. Nichols and Dr. J. C. Schelleng, who will themselves describe their conclusions in an important article in the next issue of* POPULAR RADIO.


A. T. & T. Co.

THE MOBILE RECEIVING SET USED IN THE TESTS

In order to determine the electromagnetic field strength at various places around a city, measurements are taken in small areas. This data is then plotted on a map of the city which will show approximately where the good locations for transmitting and receiving are.

HOW RADIO DEAD-SPOTS ARE FOUND BY

A Wandering Broadcasting Station

Recent tests that are of great value to the radio fan in improving reception in places where receiving is difficult or at some seasons almost impossible.

By J. O. PERRINE

RAPID fading of radio signals, differences in day and night transmission and geographical distribution, are peculiarities of radio transmission known to almost every enthusiast.

"Just how are radio waves distributed about a broadcasting station" is often a topic of discussion among the radio fans.

All of these questions are receiving effective answers through extensive ether surveys.*

For the past three years radio transmission and distribution measurements have been made in three fields, transoceanic, ship-to-shore and broadcasting.

In POPULAR RADIO of March, 1924 the diurnal and seasonal variations of signal intensity and noise revealed by transatlantic tests were reported. The present article is concerned with the distribution over city districts of radio waves from broadcasting stations.

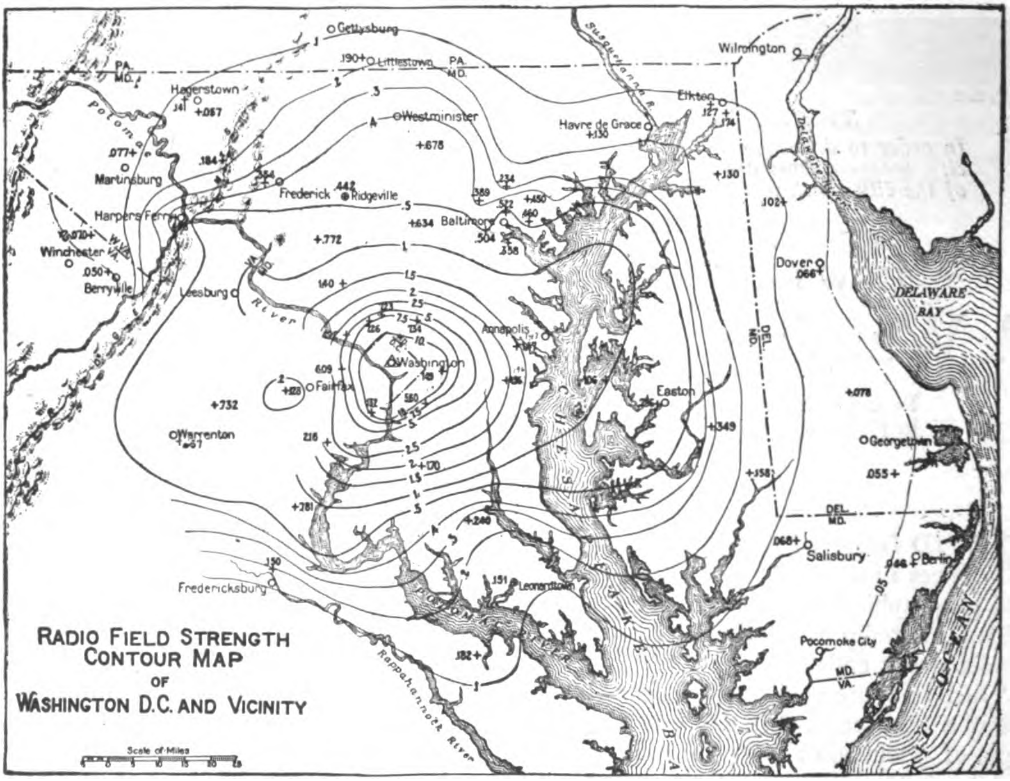
All of the work of radio transmission measurement has been made possible by the design of practical and portable apparatus by means of which the intensity of received signals can be accurately measured. The receiving set is provided with a carefully shielded local oscillator associated with the loop antenna, through a calibrated potentiometer. This system makes it possible to compare the received antenna current with similar current from the local oscillator and by calculation obtain the value of field strength in microvolts per meter; field strength being a measure of signal power. The comparisons are made through the agency of a micro ammeter at the output of the receiving set, and by this method the human ear is entirely eliminated in the actual recording of data.

---

* Carried on by the engineers of the American Telephone and Telegraph Company and the Bell Telephone Laboratories.

Using this specially designed receiving set, mounted in an automobile, it was possible to take measurements for many points in all directions and at distances varying from a few blocks to about 50 miles in the territory surrounding Station 2XY, 24 Walker St., New York City, and Station WCAP, 725 13th St., N. W., Washington, D. C. The points at which the field strength was the same were spotted on a map or airplane picture and connected by a line; "signal contour lines" they might be called.

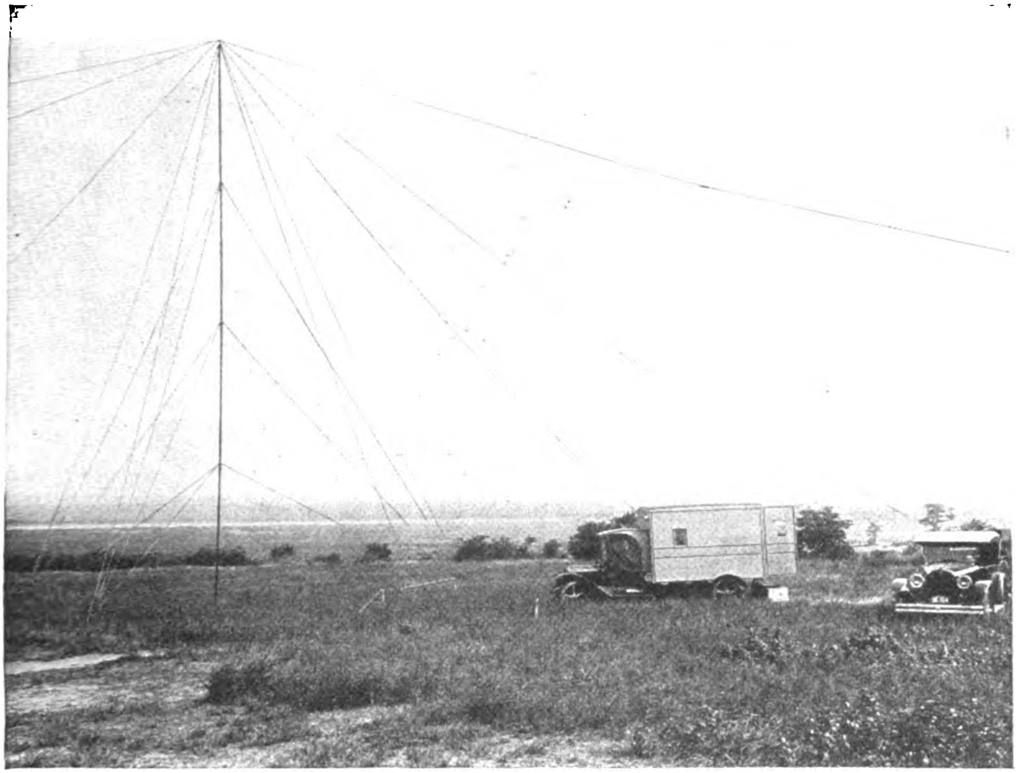
The size and location of dead spots, indicated in the accompanying chart by the closed curves, and the manner in which field strengths decrease in different directions, were disclosed. In regions where the contour lines are close together, the signal intensity is decreasing



A. T. & T. Co.

HOW THE RADIO FIELD STRENGTH AROUND WASHINGTON IS PICTURED

The distortion is less marked around the transmitting station than in New York. The effect of Chesapeake Bay to the north and south is noticeable. At locations five miles away from station WCAP, a difference of one mile makes a difference of two units of field strength. At places 50 miles away, a difference of five miles makes a difference in field strength of only one unit.



A. T. & T. Co.

THE "GYPSY" STATION 2XBE

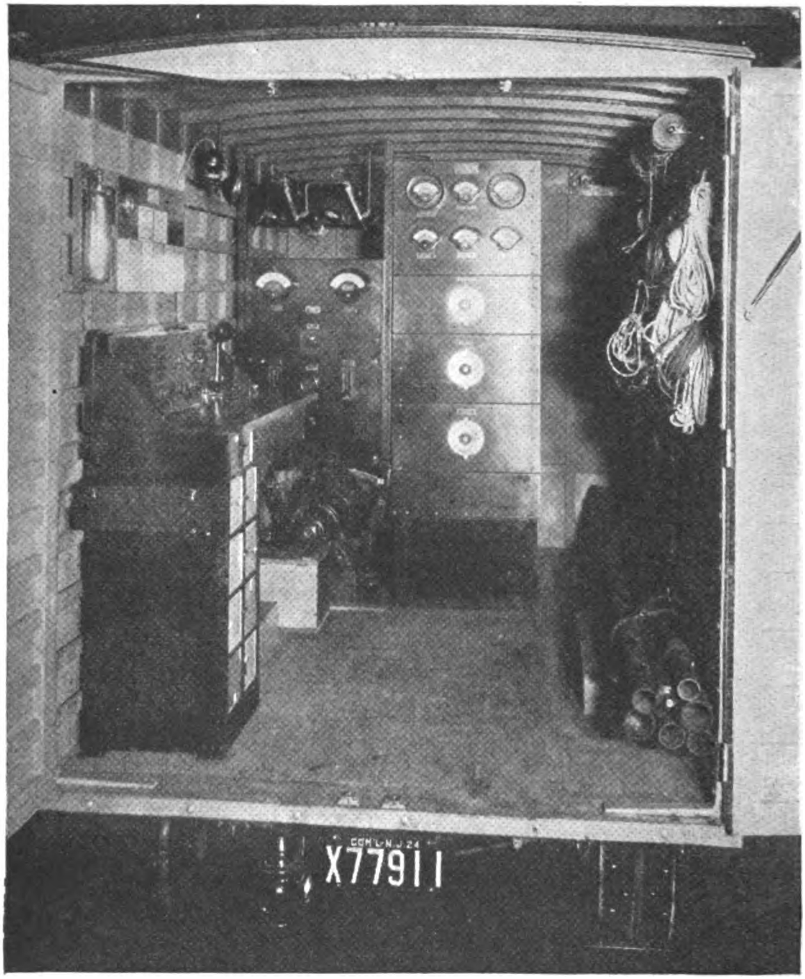
This picture shows the truck that carries the 500-watt transmitter. Alongside it is the portable antenna from which test signals are sent that tell the engineers at the receiving end the quality of the location for transmitting.

rapidly with the increased distance. An inspection of the accompanying chart will also show that at distances close to the broadcasting station one may expect signal intensity to decrease much more rapidly with distance than at great distances away. In this way, the chaotic array of qualitative impressions about radio wave distribution have been replaced by actual quantitative measurements.

Aside from the general interest derived from an examination of the curves, they also make possible some analysis of radio transmission problems.

If the surface of the earth were flat and of uniform electrical characteristics, the decrease in signal intensity, due to the spreading out of the waves and the absorption of the waves by the earth and the atmosphere, might be expressed in simple mathematical form. The many widely varying factors revealed by the great irregularity of the contour lines make it appear that a transmission formula cannot be readily set up to properly account for all of them. However, through charts and data presented in this article the reader can obtain a good picture of how water, dry land, hills, valleys and steel buildings affect radio transmission and gain insight into the allowances which radio engineers must make in their problems. The work of Messrs. Bown and Gillett here being reported disclosed the following salient points:

First: The radio attenuation over different kinds of earth surface vary widely. It is low for sea water and for flat, moist ground. For



A. T. & T. Co.

THE INTERIOR OF THE TRUCK

On the right, hanging from the side of the truck, are the wires and guys for the antenna, and below them is the collapsible antenna mast. On the left is the radio-telephone transmitter, the generator and the control panels.

dry ground the attenuation is relatively much greater. In the case of closely built cities filled with steel buildings, the local attenuation may be enormous.

Second: Sudden changes in land elevation and large masses of conducting material cast radio shadows which may be very heavy in extreme cases.

Third: Shadows cause local dead spots; but usually within a relatively short distance beyond the shadow is wiped out by refraction or diffraction.

It can be appropriately pointed out at this point that in the results enumerated above, the diminution of signal intensity results almost entirely by obstructions of various sorts on the surface of the earth and not from changes in atmospheric condition. A fraction of the radiated energy is subtracted from the outgoing waves on account of the variable character of the earth's surface. This energy is transformed into heat and therefore is lost to radio uses. Hence the topographical character of the earth's surface, together with the presence of man-made buildings, are the main factors concerned. Differences in day and night transmission are not outstanding for a resident or near-resident of New York City; actual geographical location is a point of more importance.

Ship-to-shore tests have shown that the absorbing effect of sea water remains quite constant. The great differences experienced in this case are due to wide differences in atmospheric absorption during the day and night. On some occasions it requires 10,000 times more power to "get through" as well during the worst day as during the best night.

If the decrease in signal power resulted only from the fact that the waves spread out in continuously enlarging hemispheres with no absorption effects operative, then "the inversely as the square of the distance law" would apply. Records show that during the best night conditions the signal power on some occasions seems to follow the inverse square law. Provided no directive effects were present, this might be interpreted as meaning that on these occasions both the water surface and the atmosphere were non-absorbing.

It was early recognized that the best and most comprehensive understanding of radio wave distribution, as far as broadcasting is concerned, would be obtained by making the transmitting station portable as well as the receiving station. Consequently telephone engineers have designed a traveling transmitting station. This has been constructed by the Western Electric Company, using a White truck as the conveyor. The truck is of a special type used extensively in telephone work for pulling cables through underground conduits and through the long chains of supporting rings used for aerial cable suspension.

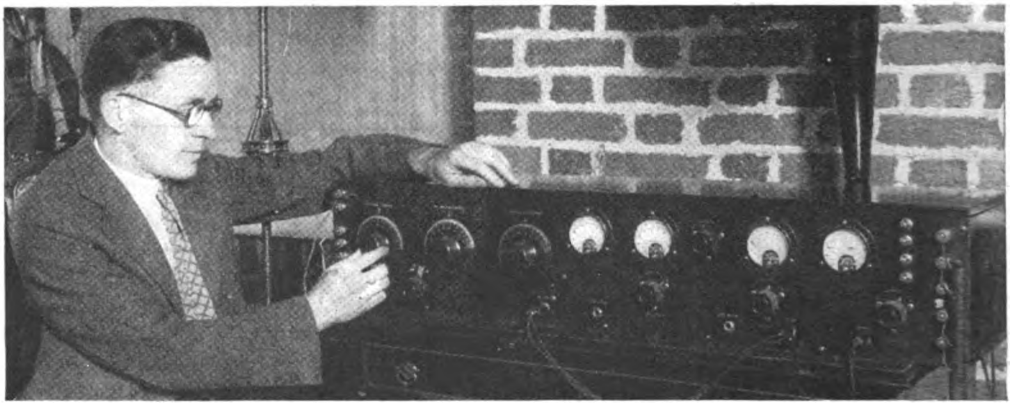
The mobile transmitter is rated at 500 watts output and employs vacuum tubes using a plate potential of 1,500 volts. One of the accompanying photographs shows the interior of the truck with the panels of the transmitting set, and on the left hand the receiving set. Government regulations require that every coastal transmitting station be equipped for listening on 600 meters, the wavelength at which ship distress signals are generally sent out. In operating this portable transmitting station, it is customary to listen continuously on 600 meters, since the messages from the truck are sent out on another wavelength.

This traveling transmitting station is known as 2XBE and undoubtedly many of the radio audience in the past have heard these call letters on the air. If so, they will understand that telephone engineers are on the job seeking to achieve their objective; to eliminate dead spots and to enable each individual in the radio audience to receive broadcast programs under the best possible conditions of clearness and loudness.

It is thinkable that to obtain a more complete picture of radio transmission, signal intensity measurements might be taken in more than one plane. In addition to obtaining contour lines for the earth's surface, lines in planes parallel and perpendicular thereto might give valuable information. In this study the airplane and dirigible might be effectively used. By having a great airship circle over a broadcasting station at varying heights and distances, additional experimental data of great importance would perhaps be made available. If measurements for high altitudes were thus obtained, one might be better able to discuss the existence of the so-called Heaviside layer, that electrically conducting sheet of rarefied air supposed to exist above the earth's surface.

How to Eliminate the "B" Battery

In a near future issue of Popular Radio *will appear a constructional article of widespread value to broadcast listeners, that represents the latest product of the* Popular Radio Laboratory.



Kadel & Herbert

THE OPERATOR SHOULD KNOW WHAT EACH ADJUSTMENT MEANS

When tuning a more complicated type of receiver, it is essential that the operator knows what happens with each adjustment and just what each one is for; otherwise he cannot obtain the best results.

When You Turn Your Dials

Few broadcast listeners actually know what is going on inside their radio receivers when they "twist the knobs." This article tells them just what happens. An understanding of these details will help *you* to tune in!

By JACQUES AVON

IT is one thing idly to turn a knob on a receiving set and another thing to tune a receiving set in a practical, scientific manner.

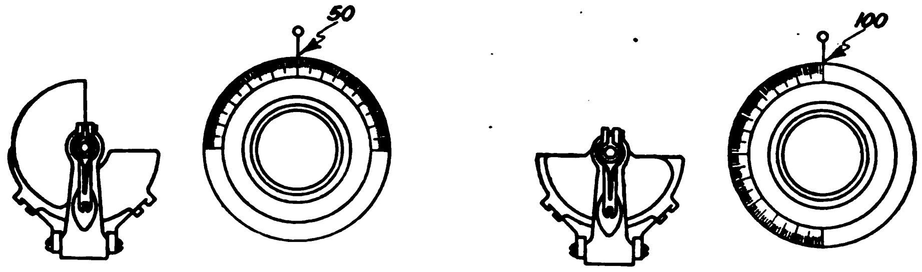
To some radio fans "knobs" are simply wheels to be turned when one wishes to listen to a broadcasting station, and they depend largely upon the "Be-Gosh-and-Be-Gad" principle of bringing about the desired results.

A tuning knob is more than a mere handle. It is a key with which we are enabled to open up the doors of the wavelength channels which we may want to use. Some fans think that the numbers on a dial are placed there to aid their memory. Perhaps they are—but this is not the only function they have.

Before we can hope to tune a radio set the way it should be tuned, it is necessary to understand thoroughly what happens when we do turn a knob. We must know what is going on behind the scenes. Secondly we must know that the knobs are set upon their shafts in such a way that we are informed of the exact position of the instruments (to which they are attached) when a particular portion of the scale is reached.

The first device to consider is, perhaps, the variable condenser, as this is by far the simplest.

Most of us know that a variable condenser is at maximum capacity when all of its plates are interleaved, when the movable plates are entirely sandwiched between the stationary plates. When setting the knob initially on the shaft, the condenser should be brought to maximum capacity as just described.



THE DIAL SETTING OF A CONDENSER

Figure 1: *The dial and the condenser (at the left of the above diagram) show the relation between a dial setting of 50 and the position of the rotor plates of a variable condenser. In this position they are half-way meshed. At the right the corresponding setting of the rotor plates is shown as fully meshed with a dial setting of 100.*

Then the dial is moved to a point where the 100 mark will be directly opposite the adjusting line marked on the panel. As the knob is turned away from this position down the scale until 50 is reached the condenser plates will be half-way interleaved. But, of course, this does not mean that the condenser is at exactly half capacity. This will depend upon the capacity curve of the particular condenser used. However, if a curve is supplied with the condenser (and some manufacturers are willing to do this) the dial attached to the knob can be calibrated so as to give an accurate indication of the capacity of the condenser, in micro-microfarads, at any point.

The radio fan, who wants to create a professional appearance while he is working over his set in the presence of friends, should never be seen turning his dials around onto the unmarked portion of the dial beyond the 100 mark.

This is ridiculous from the standpoint of the radio expert. When we reach the unmarked edge of the dial we are going through the same cycle of operations that we go through on the marked half, save that in the latter case we have little or no notion as to the relative positions of the plates of the condenser at any particular setting of the dial. As a condenser can be brought from maximum to

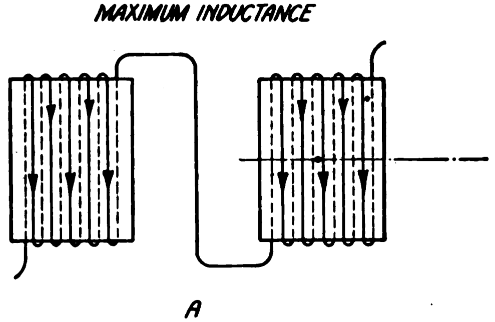


Figure 2A: *The two coils of the variometer when turned at 100 on the dial have a maximum inductance.*

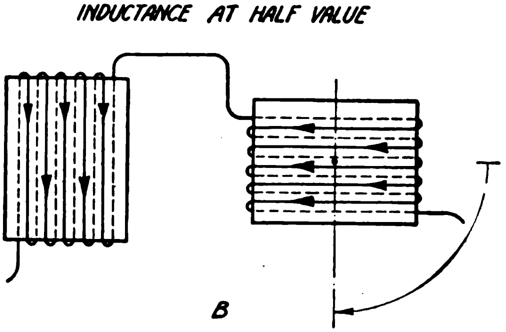


Figure 2B: *When the rotating coil is at right angles at a corresponding dial setting of 50, the inductance is a medium value.*

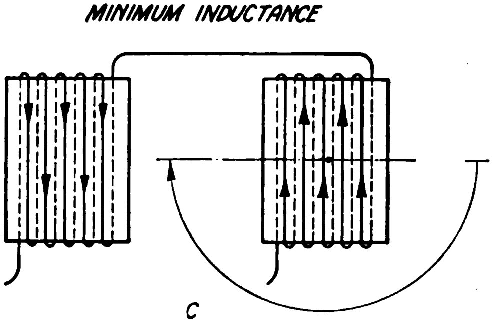
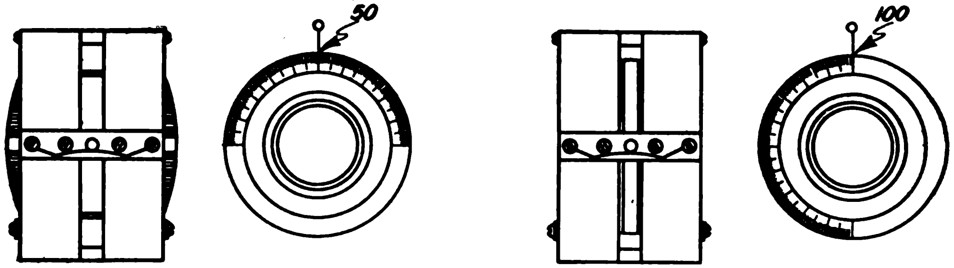


Figure 2C: *When the dial setting is at zero, the two coils oppose each other and the inductance is a minimum.*



THE DIAL SETTING OF A VARIOMETER

Figure 3: *This diagram shows (at the left) the corresponding settings for the variometer as shown in Figures 2B and 2A respectively.*

minimum capacity within the marked space of the dial, it is unnecessary to go between the 0 and 100 limits on the unmarked portion of the dial.

The second instrument of importance, that is usually controlled by a knob and dial, is the variometer.

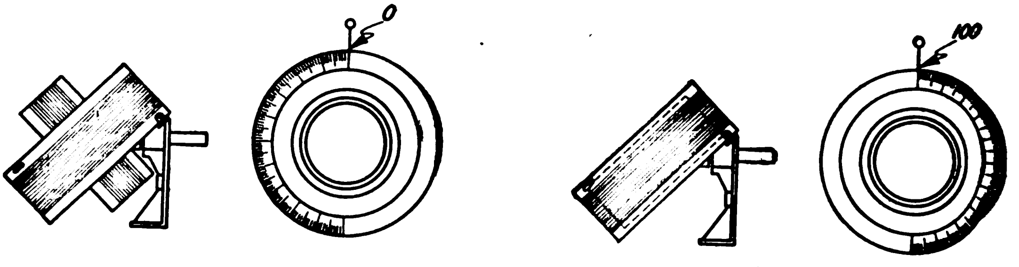
Here we are confronted with a problem essentialy different from that of the condenser, for we are controlling the second property of an electric circuit, inductance.

Inductance is, of course, controlled by several different instruments, but the variometer is one of the most important, for the adjustment obtained by means of this instrument is continuously variable.

The operation of the variometer will be better understood by reference to Figure 2. If we have two coils of wire wound in the same direction maximum inductance will be obtained when they are placed in inductive relation in the position shown at A. If, however, one coil is rotated on its axis until it has passed through 180 degrees corresponding to the 100 mark on the dial, two coils will present little or no inductance, providing they are close enough to each other to bring about an inductive relationship. Any position between these two extremes will result in placing a certain amount of inductance in the circuit.

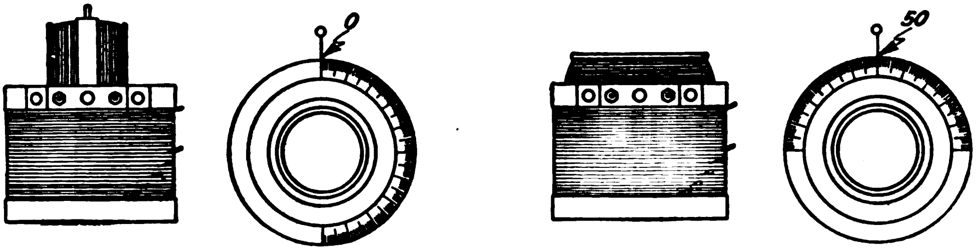
Unlike some of the other instruments used in radio, the variometer may be rotated in either direction with the result that the same increase or decrease in inductive relationship between the coils is obtained.

From the diagram it will be seen that what we actually do when we rotate one of the coils through 180 degrees is to change the direction of the current flowing through it. Hence, if there is exactly the same amount of wire in each coil—the stationary and the movable one



THE DIAL SETTING OF A VARIOCOUPLER

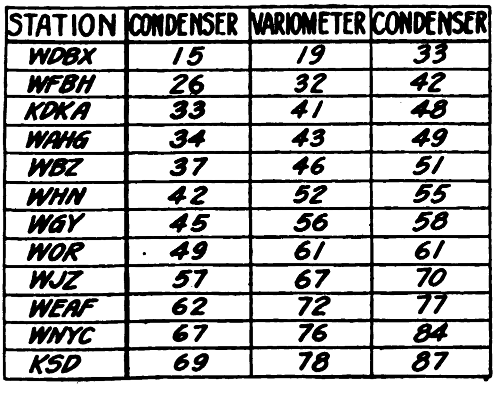
Figure 4: *At the left, corresponding to a dial setting of zero, the secondary coil (or tickler) is at right angles to the primary coil that gives minimum coupling. At the right is shown a dial setting of 100 with both coils in inductive relation whereby maximum coupling is obtained. This is true only of the 180 degree variocoupler.*



THE DIAL SETTING IN RELATION TO THE 90 DEGREE VARIOCOUPLER

FIGURE 5: *At the left is shown the position of the rotor for a dial setting of zero; this gives minimum coupling between the two coils. With this type of coupling the maximum inductive relation is obtained when the dial is set at 50. If it were revolved to 100 the minimum coupling would be again obtained.*

—the two coils will theoretically represent no inductance when they are entirely opposed to each other,* while their inductances will be added when the current is flowing through them in the same direction. To set the dial properly, we first turn the variometer to a position of maximum inductance. This can be determined by tracing the coil connections through to see that the current is flowing in one direction. Otherwise one will have to guess which position to set the dial in. When this point is reached, the dial is put on the shaft so that its 100 degree mark will be at the line on the panel. With this arrangement a 50 setting of the dial will represent approximately 50 percent of the total inductance of the coils.



STATION	CONDENSER	VARIOMETER	CONDENSER
WDBX	15	19	33
WFBH	26	32	42
KDKA	33	41	48
WAHG	34	43	49
WBZ	37	46	51
WHN	42	52	55
WGY	45	56	58
WOR	49	61	61
WJZ	57	67	70
WEAF	62	72	77
WNYC	67	76	84
KSD	69	78	87

A GOOD TYPE OF TUNING LOG FOR EVERY SET-OWNER TO KEEP

FIGURE 6: *This table shows a sample log for making a record of the settings of the instruments for given stations so that they may be readily found again.*

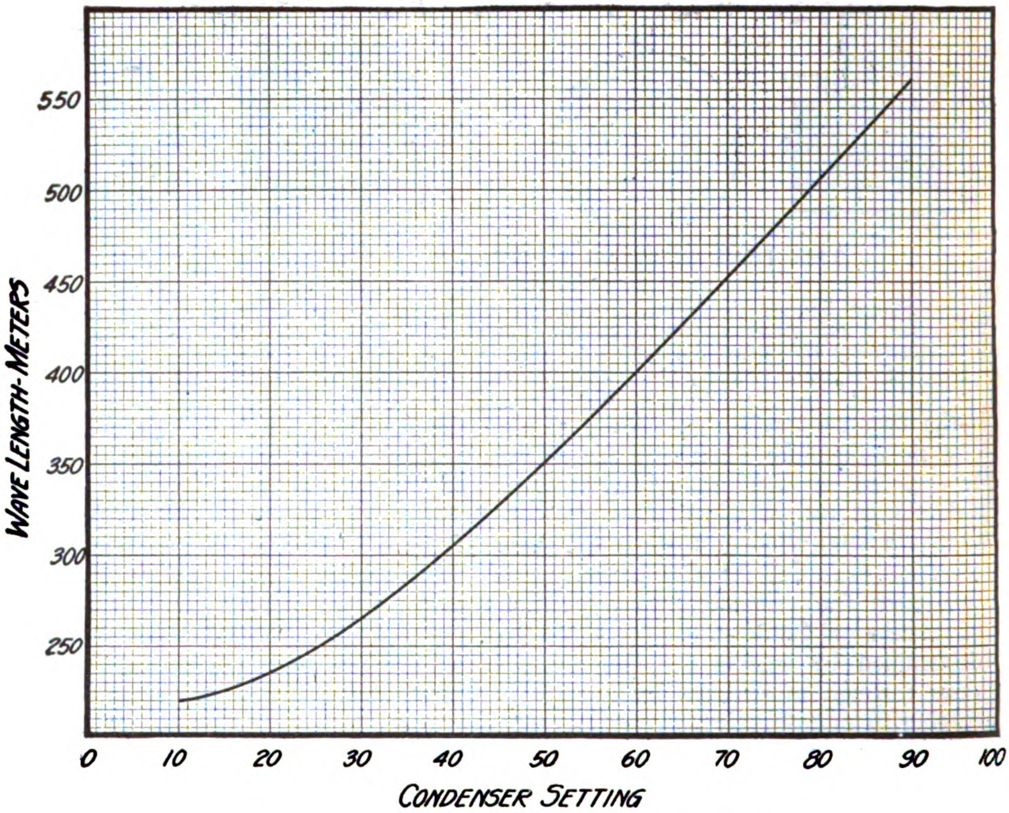
The 180-degree coupler operates in a fashion similar to that of the ordinary variocoupler. That is, minimum coupling will be obtained when the coils are at right angles to each other. We can understand this relationship when we recall that we get maximum magnetic-coupling between two coils carrying electric currents when their axes are in line with each other. If we place them at right angles to each other the coupling is reduced to a minimum because their electromagnetic fields are at right angles. When the 180-degree variocoupler is brought to the position indicated in Figure 4, the dial is set at zero degrees indicating minimum coupling. From this point there will be a gradual increase in coupling to a maximum as the dial is slowly turned to 100.

The next instrument of importance, that is controlled by the motion of a dial, is the type of variocoupler illustrated in Figure 5.

Here we have an ordinary coil of wire with a rotatable member that carries another coil arranged near it. This variocoupler, although mechanically different from the variocoupler previously described, is closely related to it and operates on the same principle. However, the rotor operates through an angle of only 90 degrees if it is provided with a stop (which it should be, for there

---

*Actually there will be some slight inductance left, as the coupling never is close enough to produce zero inductance.



A SAMPLE TUNING CURVE FOR A RECEIVER

FIGURE 7: *This chart shows how a single-control receiver might be charted to enable the setting of the tuning dial for any given wavelength. For instance, the setting for the wavelength of 350 meters, which is shown at the left-hand vertical scale, would correspond to 50 on the condenser dial. A wavelength of 450 meters would correspond to a dial setting of approximately 70. A glance at this chart will reveal the method employed.*

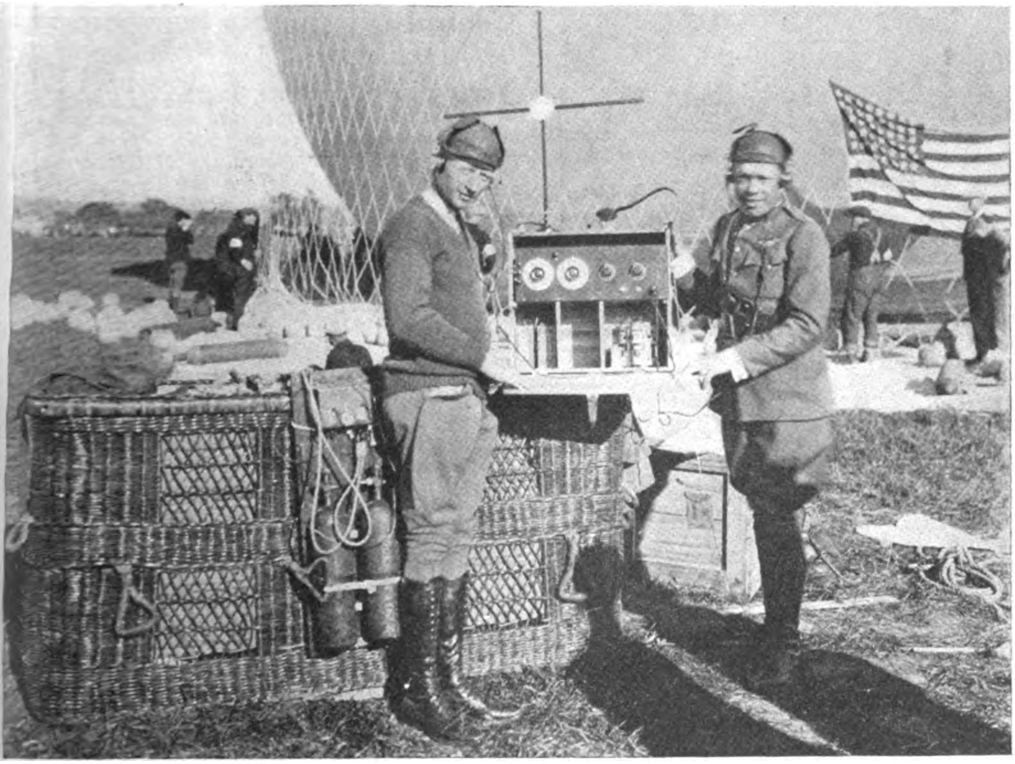
is no practical reason why it should be allowed to turn in a complete circle).

When the rotor is in such position that its sides are horizontal there is maximum inductive coupling between it and the primary coil. With this data available the fan should have no trouble in setting his dial in such a way as to have an approximate idea of the coupling in the circuit when the dial is at any one particular position. The only difference between these two types is that the first type takes one-half revolution of the dial to go from minimum to maximum coupling while the latter type takes only one-quarter revolution.

The matter of knobs, for rheostats, is also important. Too many radio fans have the mistaken idea that no vacuum tube is operating at maximum efficiency unless the filament is at full brightness. Some of them seem to think that a vacuum tube is an electric light. This idea leads to distorted reception, general circuit troubles and a heavy drain on the pocketbook for "A" and "B" batteries and for burned out vacuum tubes. Nor should one attempt to regulate the current passing through the vacuum tube by depending upon the brightness of the filament as an indication. Visual indications of this nature cannot be relied upon, nor can one return to that particular position on the rheostat where best results are obtained by merely trying to bring the filament to a certain point of incandescence. It is much better to use a small ammeter which will tell how much current the filaments are passing, or a voltmeter which will tell the proper voltage across the filaments.

With so many broadcasting stations in operation, it is difficult to remember the tuning dial settings for each one unless one has an exceptionally good memory. Of course, it is possible to make up a chart like the one shown in Figure 6. Reference to this chart any moment will show just where the station can be found on the tuning apparatus dials. This saves time and trouble, and if the condensers have verniers such an approximate setting will nearly always bring the desired results.

One exceptionally clever method of tuning is that which uses a curve similar to that shown in Figure 7. This result can be obtained by so arranging the constants of the coils and capacities that the two tuning condensers have the same setting for any particular wavelength. Of course, the condensers could be mounted on the same shaft with a single knob, which would bring about the same results. It will be seen, however, that it would be practically impossible to bring about this result unless both the condensers were working in unison in this fashion. It will be a simple matter to use this type of chart with some of the simplified single-control sets that are now coming into general use.



RADIO PLAYS A PART IN A BALLOON RACE

When these two aeronauts set forth from St. Joseph, Mo., on May 1 in the Army balloon S-14, they carried radio receiving sets with them—largely in order to obtain advance information about weather conditions.

The MEN WHO

9th Installment

The Scientist Who Added a "C" Battery to the Receiving Circuit

One of the men responsible for the radio successes of the United States Navy was **Fritz Lowenstein.** *He studied, especially, the effects of controlling the grid potential by a biasing voltage. One of his inventions is that of adding a "C" battery to the receiving circuit.*

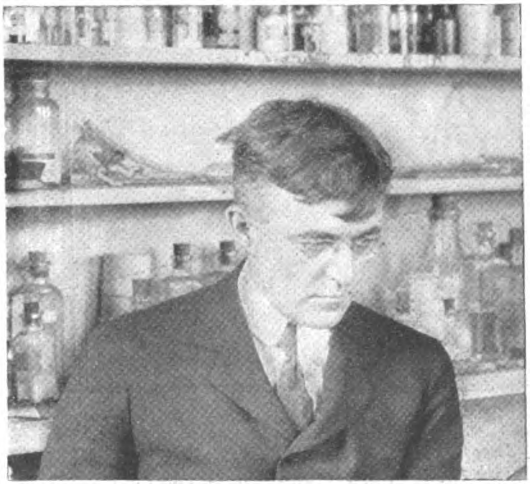
❦

International

An Authority on the Radio Control of Machinery

John Hays Hammond, Jr., *son of the distinguished engineer of the same name, has devoted his active life to radio experimentation. In his private laboratory at Gloucester, Mass., he perfected, before the war, devices for the control of unmanned ships, torpedoes and other craft by radio signals. Mr. Hammond is the inventor, also, of the system of preventing radio interference by means of double modulation—a system now in use by the Radio Corporation of America.*

❦



General Electric

The Inventor of the Langmuir Vacuum Pump

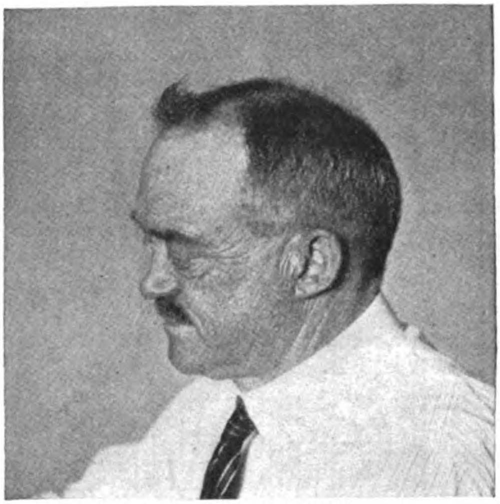
Dr. Irving Langmuir, *distinguished physicist and research worker in the Schenectady laboratories of the General Electric Company, is known in radio for his work on the space charge inside vacuum tubes and for his perfection of the thoriated filament, which filament has a much greater electron emission than can be obtained with ordinary tungsten wire. Dr. Langmuir is also the inventor of the Langmuir mercury-vapor pump, a device for attaining very high degrees of vacuum in vacuum tubes or other apparatus.*

MADE RADIO

The Creator of the Grimes Inverse Duplex System

*D*AVID GRIMES *is the inventor of the "inverse" method of employing the reflex principle, of which the well-known "Grimes inverse duplex" circuit is an illustration. By this principle the one of a succession of amplifier tubes which has the smallest radio-frequency load is made to carry the largest audio-frequency load, thus equalizing the work of the tubes.*

◆



From a photograph made for POPULAR RADIO

The First Scientist to Send Pictures by Radio

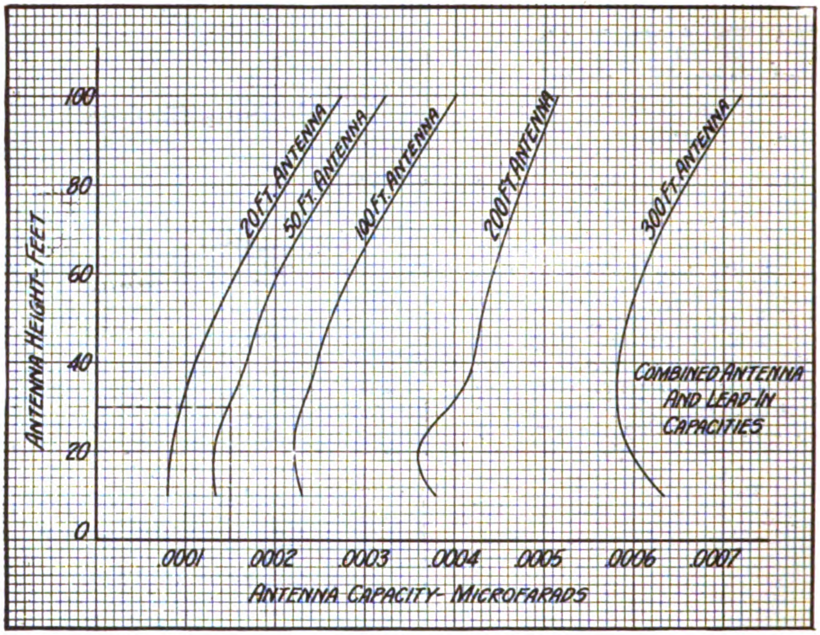
IN *inventive circles* C. FRANCIS JENKINS *is known as the man who perfected the first adequate motion-picture projector as well as many other inventions. Turning his attention to radio, Mr. Jenkins devised the first successful apparatus for transmitting pictures by radio. He is now at work on the problem of the radio transmission of motion pictures, a step toward radiovision.*

◆

Underwood & Underwood

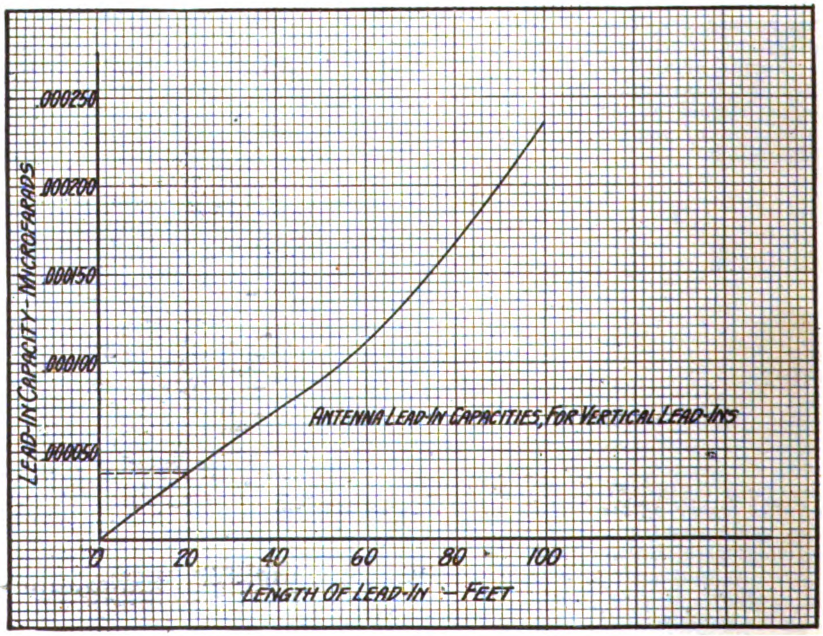
The Inventor of the Reinartz Receiver

JOHN L. REINARTZ *is one of the best known of American radio amateurs. His modiication of the fundamental Hartley circuit has een built and used by thousands of amateurs. This "Reinartz receiver" is now proving esecially successful in work with the new short waves, below one hundred meters in waveength. Mr. Reinartz is now with the MacMillan expedition in the Arctic.*



FOR DETERMINING THE CAPACITY OF AN ANTENNA

FIGURE 1: *This chart of curves shows the variation of capacity in an antenna with the variation of antenna height and length. The uneven portion of the curves of the 100 foot to 300 foot antenna is due to the capacity of the lead-in wire.*



FOR DETERMINING THE LEAD-IN CAPACITY

FIGURE 2: *The variation in capacity for straight vertical lead-in wires of varying heights is illustrated on this chart.*

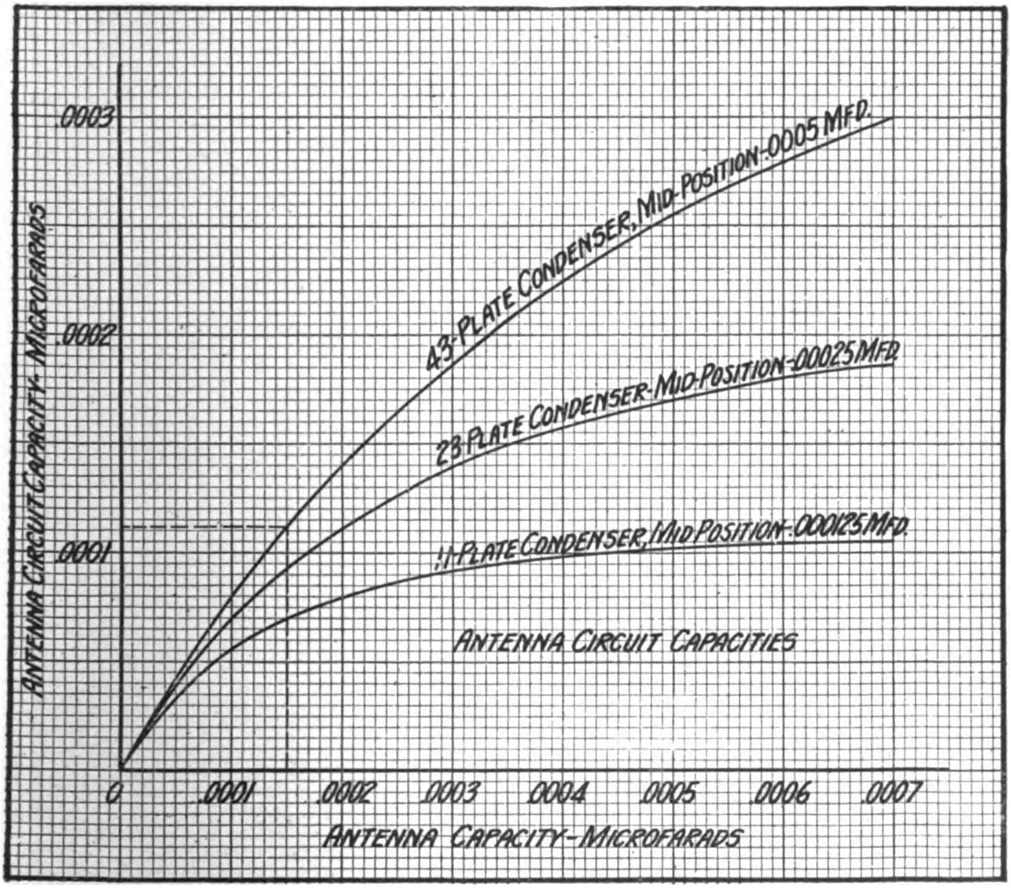
Useful Charts *for* Amateurs

Authoritative information tables for the guidance of experimenters who design or build radio receiving sets

By LIEUT. C. C. TODD, JR., U. S. N.

AS a rule, most amateurs get their hook-ups from friends, or from popular literature on the subject. This information, while good, is as a rule incomplete as far as the individual is concerned, and there are generally a number of points left in doubt when the amateur attempts to apply the information to his particular needs.

The curves accompanying this article have been prepared to furnish the information necessary to amateurs in building radio sets, and at the same time to present this information in the



FOR DETERMINING TOTAL ANTENNA CIRCUIT CAPACITY

FIGURE 3: *This chart shows the average capacity for the combined antenna circuit when using condensers of different sizes. The values are given for the mid position of each of the condensers.*

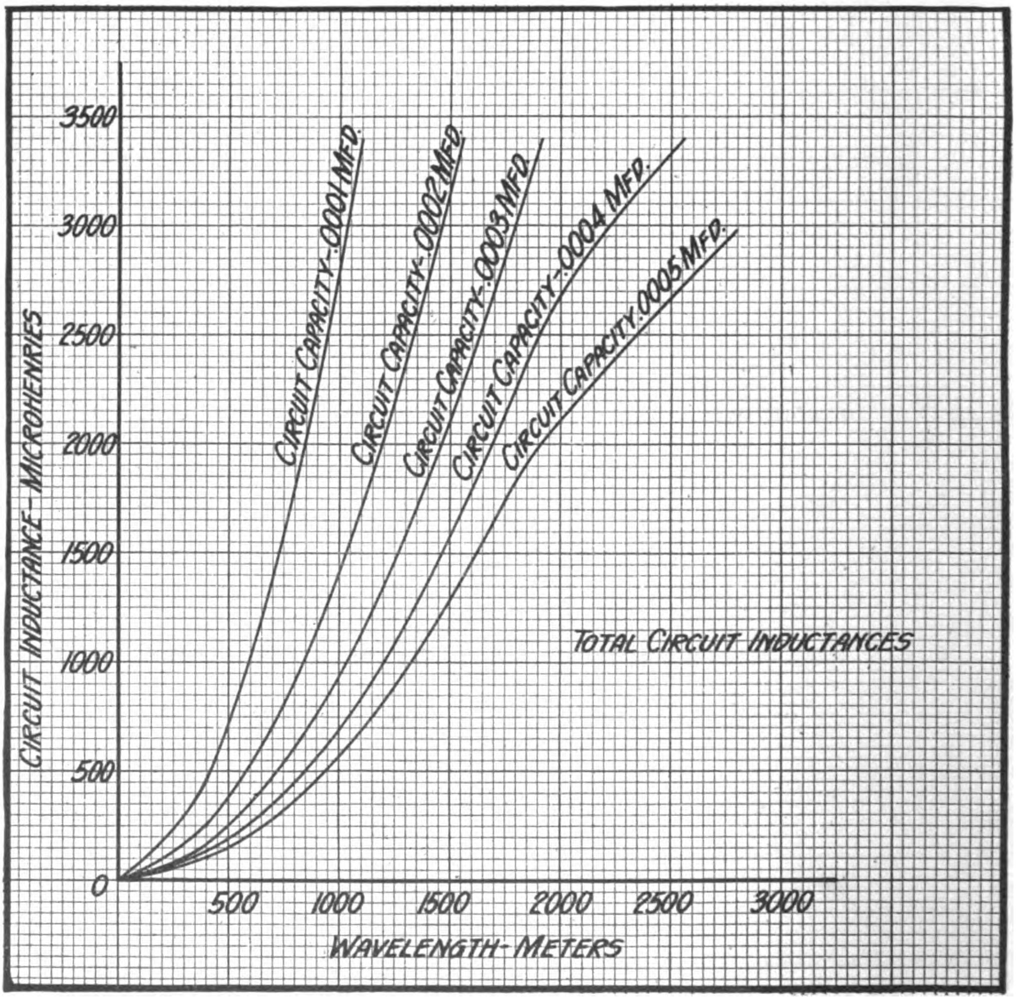
simplest and most convenient form for amateur use.

The curves are based on formulas to be found in the circular of the Bureau of Standards, Number 74 (issue of March, 1918) and on a formula for the inductance of coils which was developed by Dr. L. A. Hazeltine, of Stevens Institute. The curves are not intended to furnish *exact* data, but will furnish information far superior to "guesses," and they will eliminate a large amount of experimental work on the part of the amateur.

Let us work out a typical design to illustrate the use of the curves:

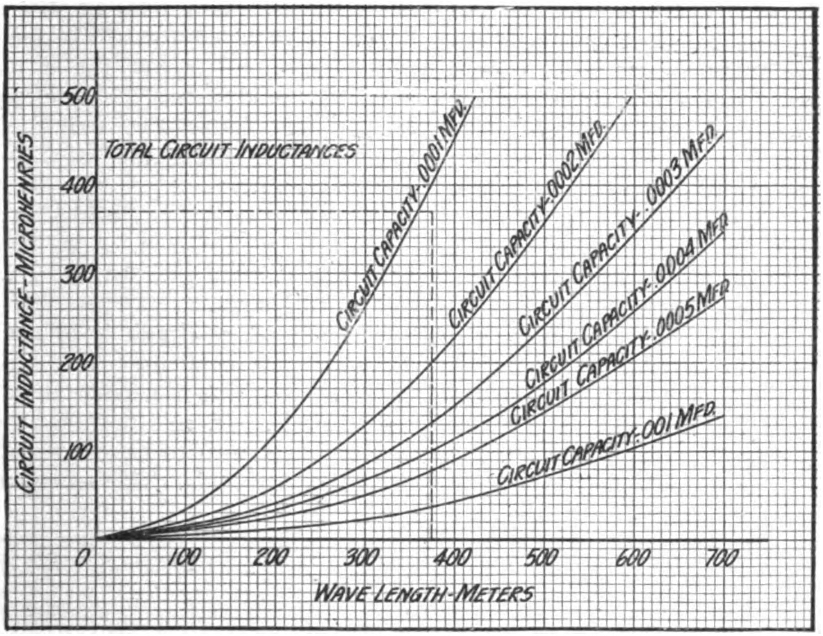
The first consideration, in the design of radio receiving sets, is the space available for the location of the antenna. The single wire (No. 14 B. & S. gauge copper wire) is generally the most satisfactory for amateur use. Let it be assumed that there is available a 50 to 100 foot span, 30 feet high, where an antenna can be strung, and that the lead-in is 30 feet long, practically vertical.

The second consideration is the type of set to be built. A radio set, like any



FOR DETERMINING THE INDUCTANCE AND CAPACITY FOR LONG WAVES

FIGURE 4: *In this chart is shown a series of curves for condensers of various capacity so that the experimenter may choose the proper inductance for his coils to cover a specified wavelength range. (For wavelengths below 500 meters consult Figure 5.)*



FOR DETERMINING INDUCTANCE AND CAPACITY FOR SHORT WAVES
FIGURE 5: *This chart gives the same kind of information as that in Figure 4, except that the wavelength range is lower than shown in the preceding chart and, therefore, a more accurate value of inductance may be determined.*

other piece of apparatus, will work best if designed for a particular duty. It is, therefore, unwise to try to design a receiving set to work over too great a range of wavelengths. It is better to design the coils of a set to a particular band of wavelengths, and to have several sets of coils to cover the entire range of wavelengths in which the amateur is interested. This last feature would lead to the choice of a 3-circuit set, having a primary or antenna inductance coil; a secondary inductance coil, and a plate-circuit or tickler coil. This naturally suggests some form of coil easily wound, small in size, and efficient. The pancake form of coil answers these requirements; consequently pancake coils of 2½-inch inside diameter may be chosen.

The necessary condensers will be one 43-plate variable; one 23-plate variable, and one .001 microfarad fixed condenser; together with the grid leaks and condensers recommended by the manufacturer of the vacuum tubes.

Grid condensers for use with detector tubes are usually about .00025 microfarads. Grid leaks of about 1 or 2 megohms are found best.

The rest of the equipment should be of reliable manufacture.

An examination of Figure 1 shows that for an antenna height of 30 feet and a length of 50 feet, the combined antenna and lead-in capacity will be about .00015 microfarads.

Figure 2 need not be consulted unless the lead-in is longer or shorter than the height of the antenna. If the length of the lead-in differs from the antenna height, the antenna capacity should be corrected by the amount of the lead-in capacity corresponding to this difference. For example: if the length of the lead-in were 10 feet, instead of 30 feet, .00004 microfarads (corresponding to 20 feet in Figure 2) should be subtracted from .00015 microfarads to obtain the antenna capacity.

With the value of .00015 microfarads and the 43-plate condenser curve in

Figure 3 it will be found that the antenna-circuit capacity is equal to about .00011 microfarads.

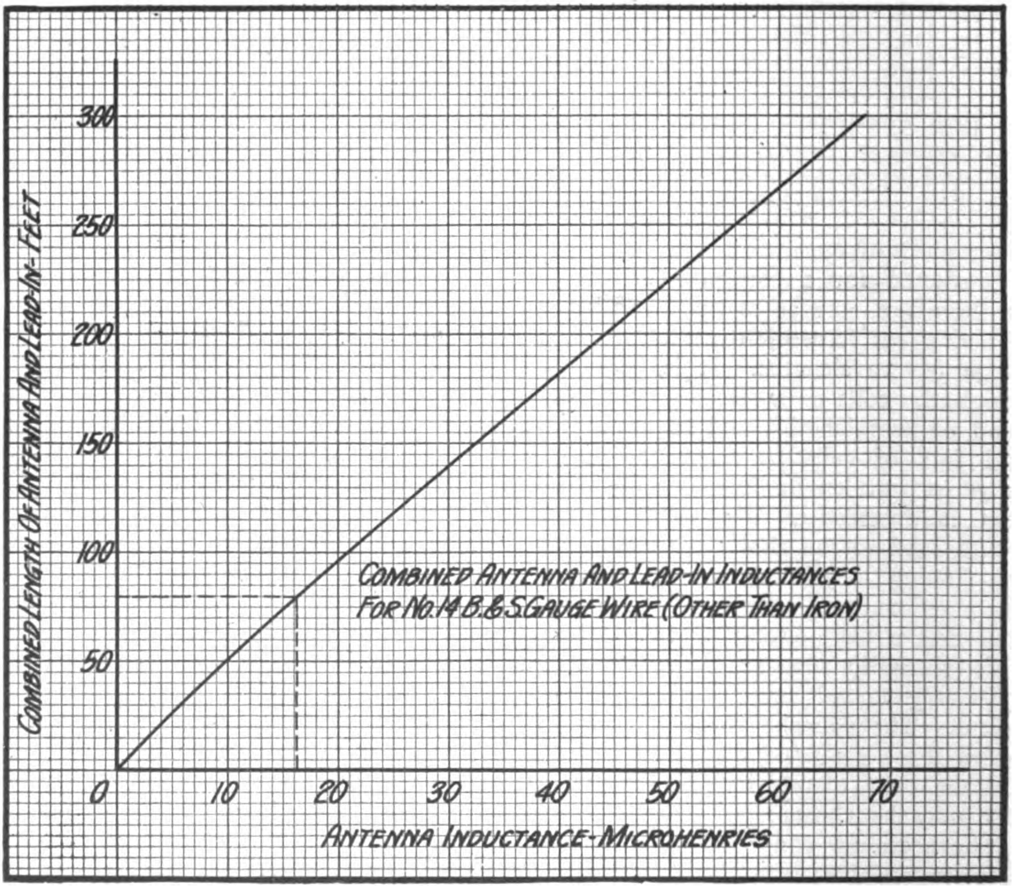
Let it be assumed that it is desired to design the receiving set for an average wavelength of 375 meters. With a wavelength of 375 meters and a circuit capacity of .00011 it is found that (from Figure 5) the primary circuit (antenna circuit) should have an inductance of 370 microhenrys.

Figure 5 should be used for greater wavelengths than covered by Figure 4.

The combined length of the antenna and lead-in is 50 feet plus 30 feet, or 80 feet. From Figure 6 it is found that the antenna inductance is about 16 microhenrys. As a total of 370 microhenrys is required for a wavelength of 375 meters, and it was found that the antenna would furnish 16 microhenrys, the primary inductance coil should be wound for an inductance of 370-16, or 354 microhenrys.

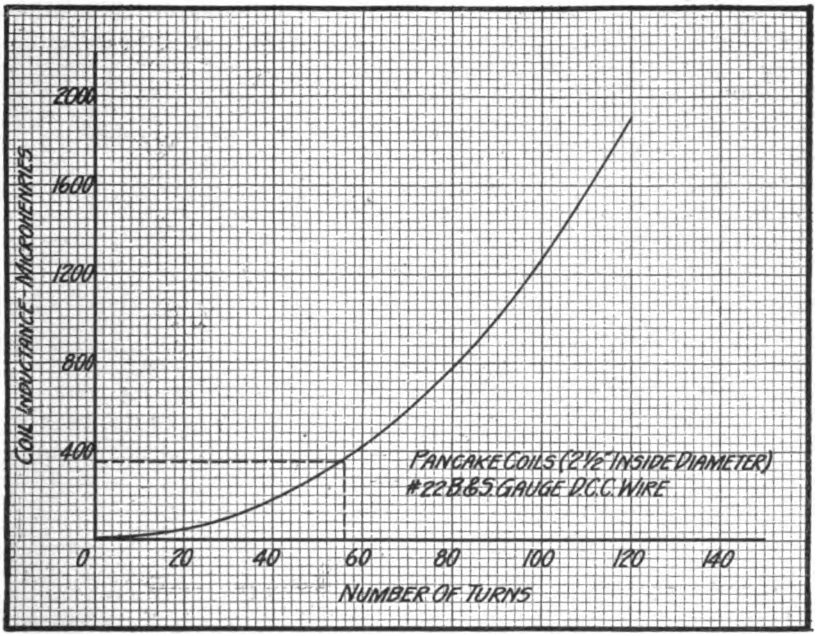
From Figure 7 it is found that a pancake coil of 2½-inch inside diameter and 56 turns will give an inductance of 354 microhenrys.

The secondary circuit is to use a 23-plate variable condenser, the maximum capacity of which is usually about .0005 microfarads. In mid-position the condenser is assumed to have a capacity of .00025 microfarads. The secondary cir-



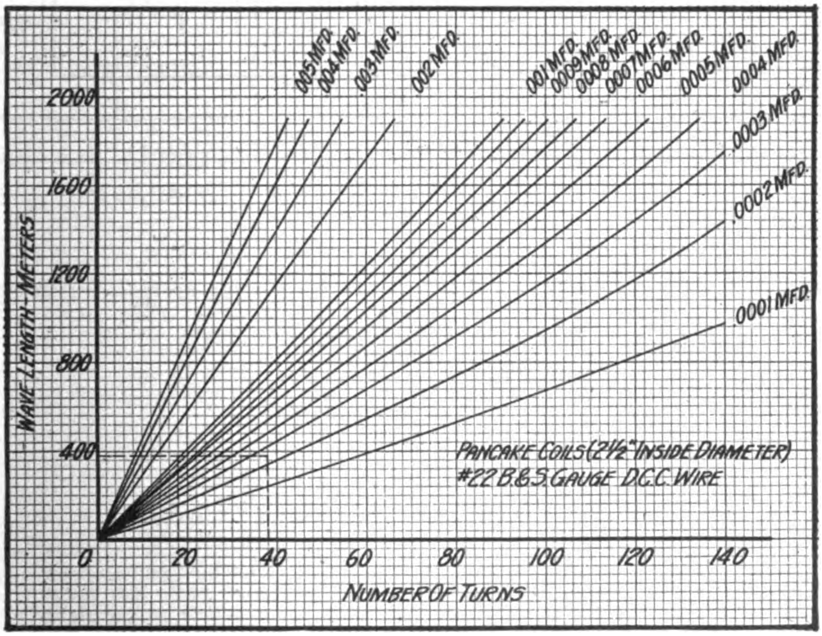
FOR DETERMINING ANTENNA INDUCTANCE

FIGURE 6: *This chart gives the variation of antenna inductance in microhenrys with the combined lengths of the antenna and the lead-in in feet. From it the experimenter may determine the inductance of his antenna system.*



FOR DETERMINING THE INDUCTANCE VALUE OF PANCAKE COILS

Figure 7: *This chart gives the inductance value for pancake coils made with No. 22 BCC wire with an inside diameter of 2½ inches. The values are given for coils containing approximately 10 to 120 turns.*



FOR DETERMINING THE COIL AND CONDENSER SIZES FOR VARIOUS WAVELENGTHS

Figure 8: *This chart tells the size of coil to use shunted by the proper size condenser for a given wavelength range. It is valuable in determining proper constants for secondary and tickler circuits.*

cuit is to work on 375 meters wavelength, so from Figure 8 with a wavelength of 375 meters and a capacity of .00025 microfarads it is found that a pancake coil of 2½-inch inside diameter with 38 turns is required.

It is decided to use a .001 microfarad fixed condenser as a by-pass condenser around the telephones or the primary of the first-stage amplifying transformer. From Figure 8 with a wavelength of 375 meters and a capacity of .001 microfarads it is found that a pancake coil of 2½-inch inside diameter with 18 turns is required for the plate circuit or tickler coil.

The results of this hypothetical design are as follows:

Antenna length	50 feet	*No. 14 B. & S. gauge copper wire*
Antenna height	30 feet	
Antenna lead-in	30 feet	
Antenna capacity	.00015 microfarads	
Antenna inductance	16 microhenrys	
Antenna circuit capacity	.00011 mfd.	
Secondary circuit capacity	.00025 mfd.	
Plate circuit capacity	.001 mfd.	
Primary (Antenna) circuit inductance coil	56 turns	*2½-inch inside diameter pancake coils*
Secondary circuit inductance coil	38 turns	
Plate-circuit (tickler) inductance coil	18 turns	

The hook-up to use with this arrangement of coils is shown in Figure 9.

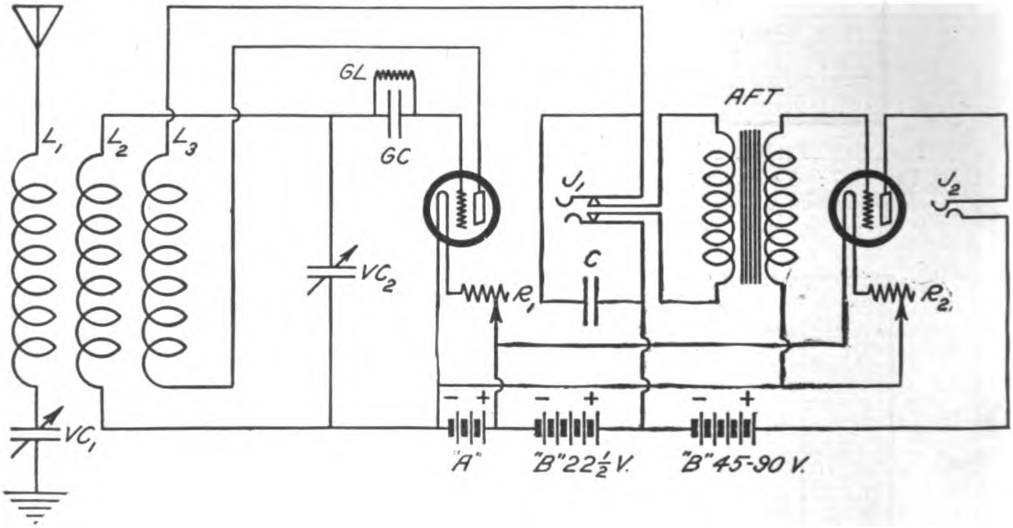
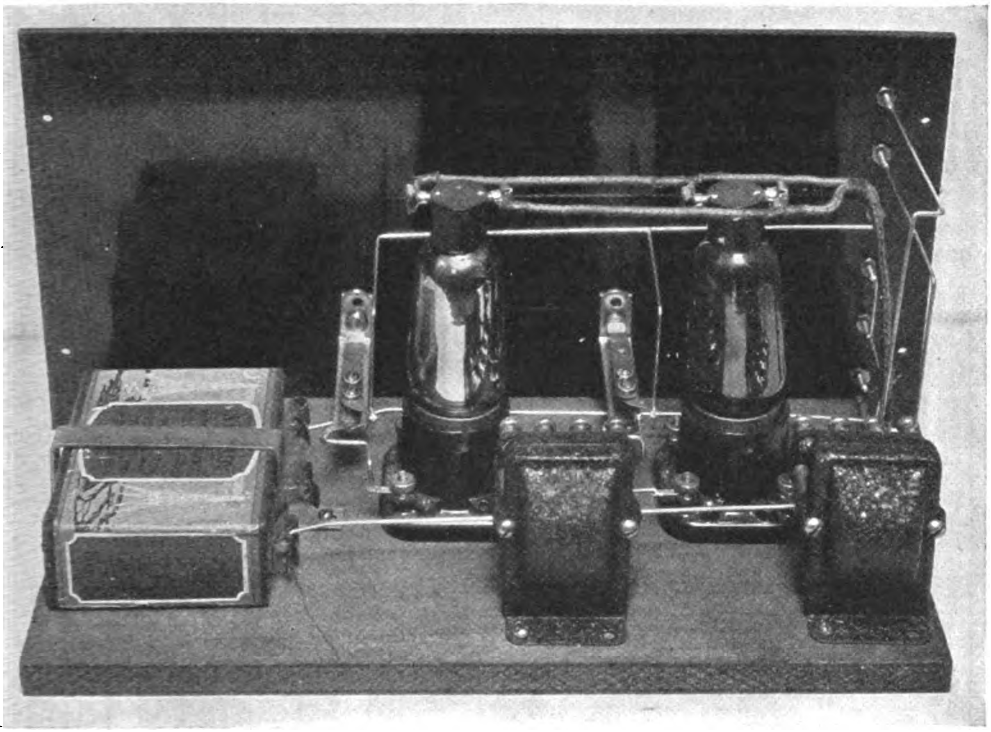


FIGURE 9: *A circuit for a triple-coil receiver with one-stage of radio-frequency amplification.*

What Makes a "Low-loss" Coil?

RADIO *fans and experimenters usually connect the term "low-loss" coil with some sort of multi-layer coil which contains no dielectric supporting material. Some interesting facts that show this is not the case will be presented in an article in the next issue of* POPULAR RADIO*—for October.*



THE REAR VIEW OF THE AMPLIFIER

FIGURE 1: *Study this view in connection with the picture diagram of the hook-up, Figure 2. The location and connecting points of each wire appear clearly and you may determine just how to bend the wires to get the shortest connection with the proper clearance.*

Simple "How-to-Build" Articles for Beginners

No. 11

How to build a two-stage audio-frequency amplifier for AC tubes

By LAURENCE M. COCKADAY

COST OF PARTS: *Not more than $23.00*

HERE ARE THE ITEMS YOU WILL NEED—

- A and B—Precise audio-frequency transformers, No. 285;
- C and D—Kellogg sockets;
- E—Brooklyn Metal Stamping Corp. single-circuit jack;
- F—Brooklyn Metal Stamping Corp. double-circuit jack;
- G—Hard rubber panel, 7 inches by 14 inches;
- H—Hardwood cabinet for 7 by 14 inch panel;
- I—Baseboard, 12½ inches by 6½ inches;
- 6—Eby binding posts.

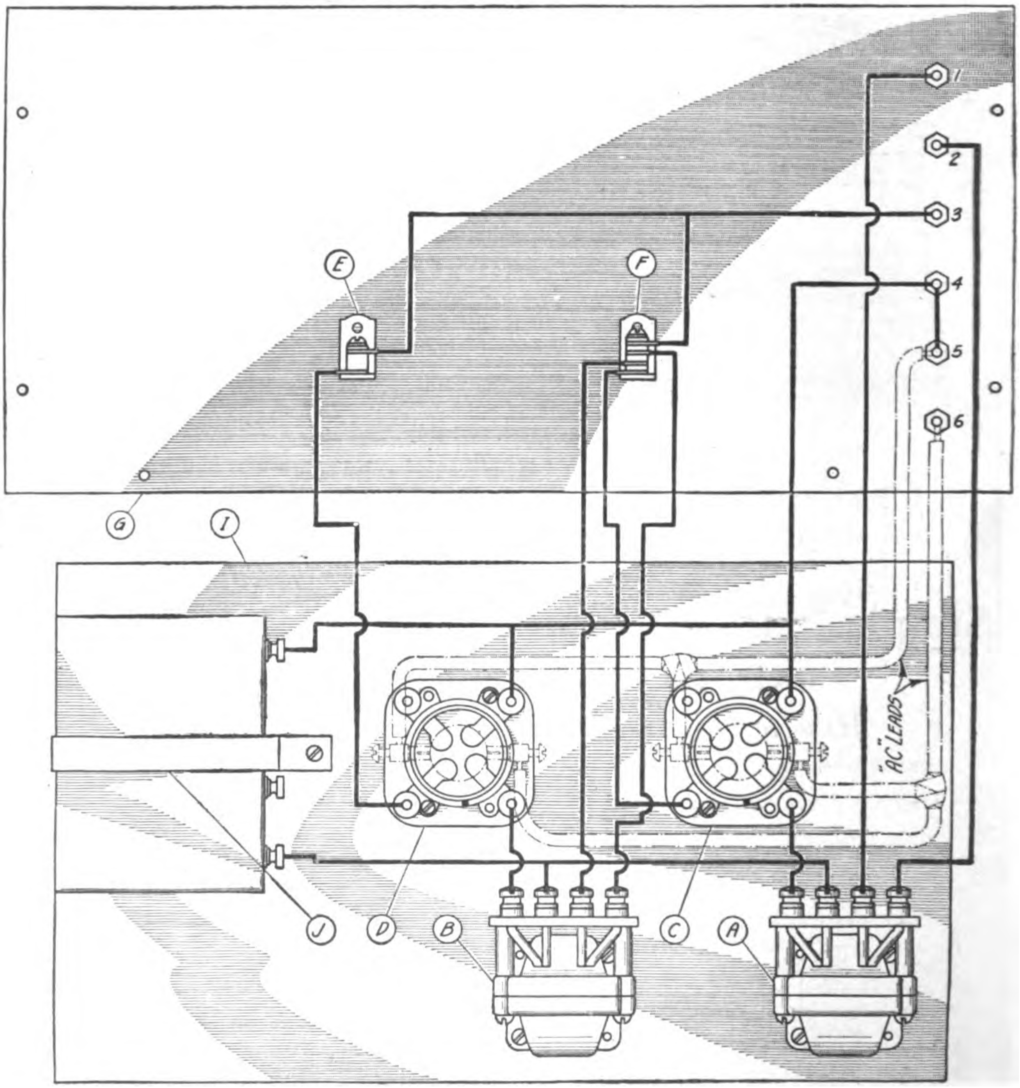
THE eleventh instrument to be described in this series of simple "how-to-build" articles is a vacuum-tube amplifier that comprises two stages of transformer-coupled amplification for use with the new McCullough AC tubes.

This unit will be found efficient when used with any of the preceding units and tuners described in this series or where-ever a two-stage, audio-frequency amplifier of the usual type is satisfactory.

This particular unit was built in the POPULAR RADIO LABORATORY for the purpose of supplying the beginner with details of an efficient amplifier that utilizes the new AC tubes and for acquainting him with its operation.

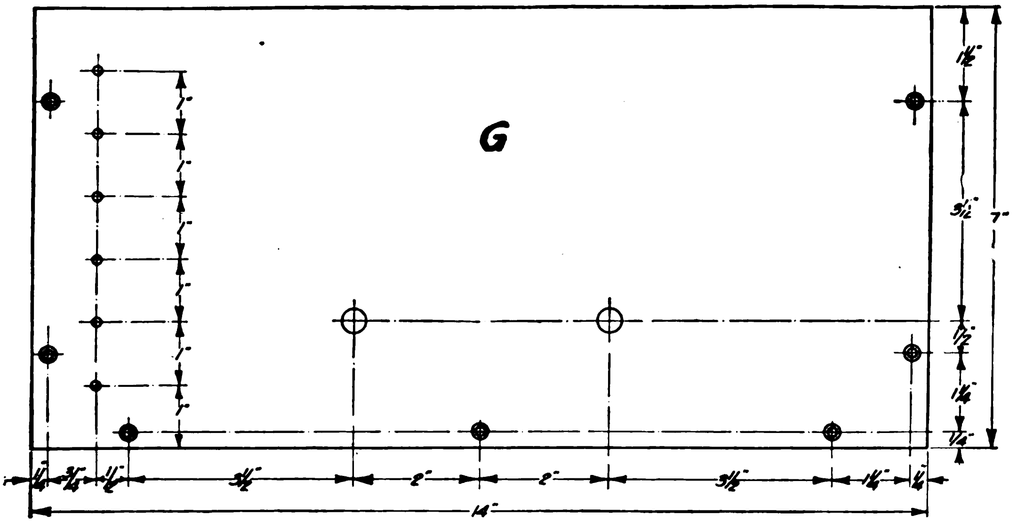
Take the list of parts (given at the beginning of the article) to your radio dealer and ask him to supply you with them.

After you have obtained all of them, find a satisfactory table or bench on which to work and lay out the parts on the baseboard as shown in Figures 1 and 2.



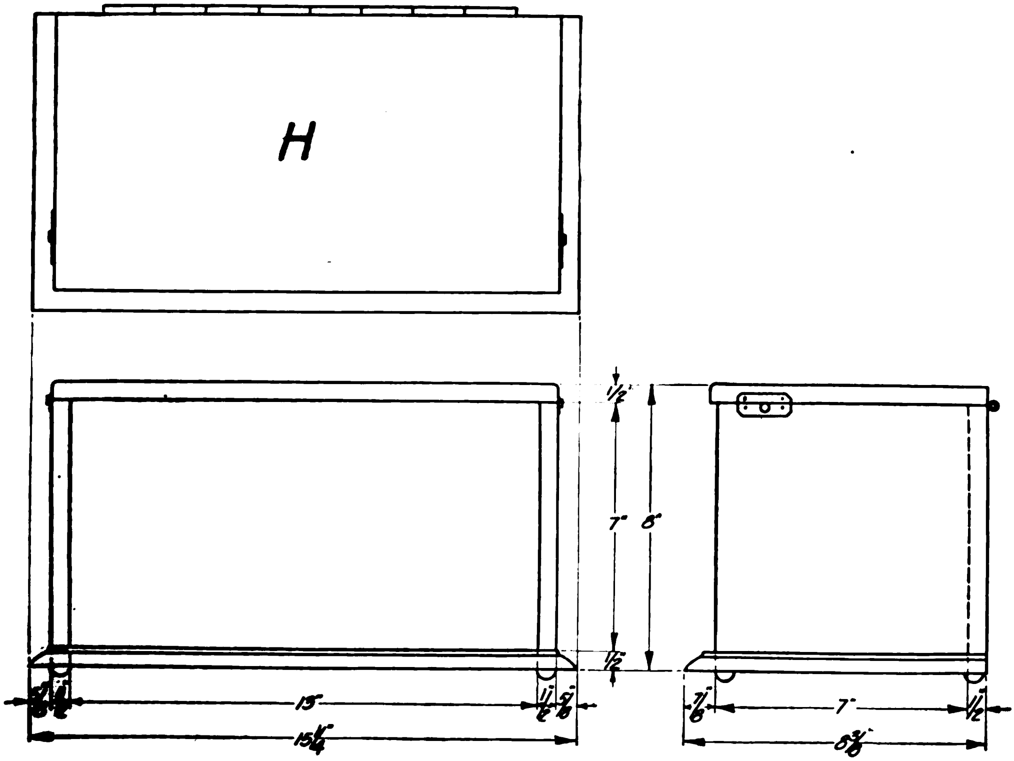
THE "PICTURE DIAGRAM" OF THE HOOK-UP

FIGURE 2: *The illustration shows the exact manner in which the instruments are placed on the panel and baseboard and how the wires run in relation to them. The upper rectangle shows the back of the panel, and the lower one shows the baseboard. All the parts are lettered to correspond with the designations in the text and in the list of parts.*



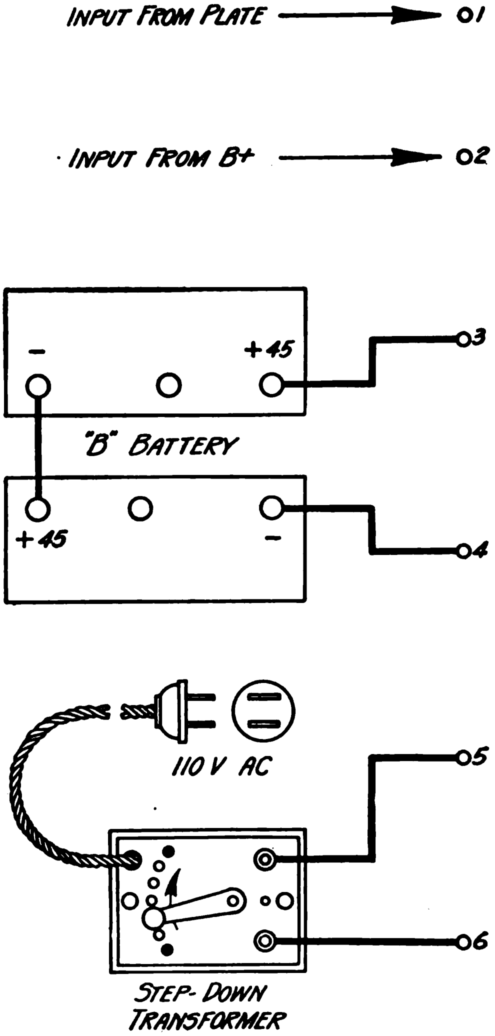
THE PANEL LAYOUT

Figure 3: *This drawing gives the dimensions for the front panel and the correct spacing from center to center for the holes that are used to mount the instruments and the binding posts as well as the holes for attaching the panel to the cabinet.*



THE DIMENSIONS FOR THE CABINET

Figure 4: *This diagram (which contains the top, front, and side measurements for the walnut cabinet) may be turned over for construction to a competent cabinet maker who can build it from these directions exactly the right size for the panel.*



HOW TO HOOK UP THE BATTERIES AND THE TRANSFORMER

FIGURE 5: *This drawing prevents you from making mistakes in making connections from the batteries and the step-down transformer to the terminals of the amplifier. If you follow these instructions the unit will be hooked up correctly because the binding posts shown in the picture wiring diagram are marked with designating numbers that correspond with the numbers given here.*

The grid post G of the sockets should be located immediately below the G post on the transformer as shown. Only two screws on diagonal corners of the sockets and transformers need be used to fasten them to the baseboard.

The panel should then be laid out and drilled. To minimize the possibility of spoiling the looks of the panel by making scratches in the wrong place, cut out a piece of paper the exact size of the panel. The position for the holes should then be marked on this using the dimensions given in the panel drawing in Figure 3. This is then used as a template by holding it on the panel carefully and punching through it with a sharp instrument of some kind at the required points. The dimensions of the holes have not been given, but the builder may readily determine the size of drill to use by noting the size of the jack nuts and the binding-post screws.

After the panel is drilled it should be fastened to the baseboard with one-inch nickel-plated screws. Flat-head screws should be used and the holes in the panel should be countersunk to make a neat job. The holes which require countersinking have a double ring drawn around them in Figure 3.

The 4.5-volt "C" battery should be fastened to the base with a brass strip bent and fastened with two small wood screws as shown in Figure 1.

This battery will last almost as long in the set as when it is not in use, due to the very light drain on it. It may readily be replaced, when necessary, by removing the brass retaining strip J, and disconnecting the two leads to the battery.

You are now ready to wire the set and should have no difficulty if the picture diagram is carefully followed. All parts are lettered with their designating letters used in the parts required list and this eliminates the possibility of a mistake.

When the wiring has been completed the set should be fastened into a cabinet of the sizes shown in Figure 4.

Figure 5 shows how the batteries and the transformer should be connected to the completed set. Although the binding posts have been placed so as to simplify connections to any of the preceding units described in this series, they also correspond to those used on most standard tuning units. Having the two step-down transformer leads (corresponding to the usual "A" battery leads) at the left of the panel makes it possible to connect these two to the preceding unit when the latter is also designed to use AC tubes of this type. This minimizes induction from long leads carrying alternating current.

Two flexible leads made of ordinary lamp cord (or similar wire) should be run from the two bottom binding posts to the heater terminals on top of the tubes as shown in Figures 1 and 2. To make these leads readily removable four friction clips of the type designed for these tubes should be soldered to the two leads.

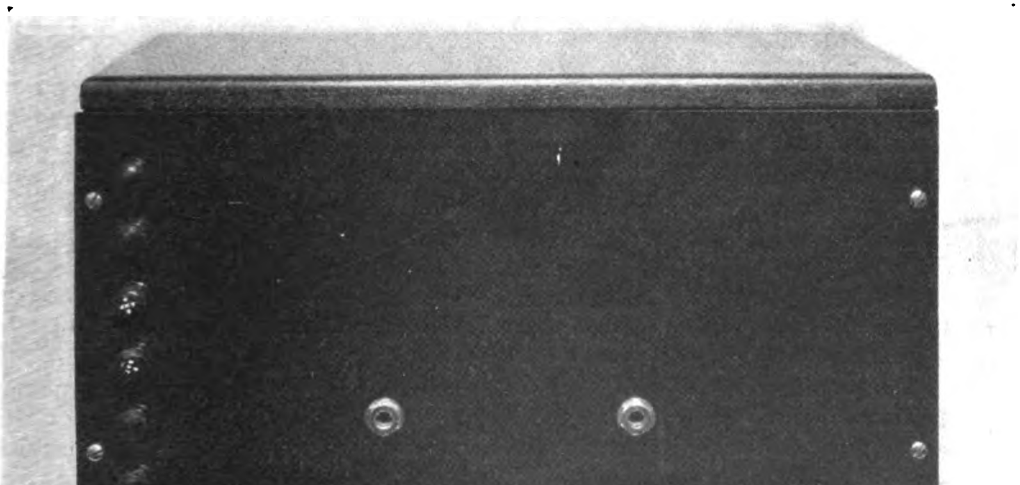
These tubes operate best with from 3.25 to 4 volts on the heater circuit and a small step-down transformer designed for this special use should be employed to supply this current. Care must be taken in obtaining the transformer to be sure it furnishes the proper values of voltage and preferably that it allows considerable variation over this range.

As is also the case with the usual filament type tube the heater coils should be run at as low a voltage as possible consistent with good reproduction and volume, so as to insure long life.

In adjusting the filament circuit make changes slowly as there is a time lag of some ten or fifteen seconds before variations in the applied voltage cause much of a change in the electron emission.

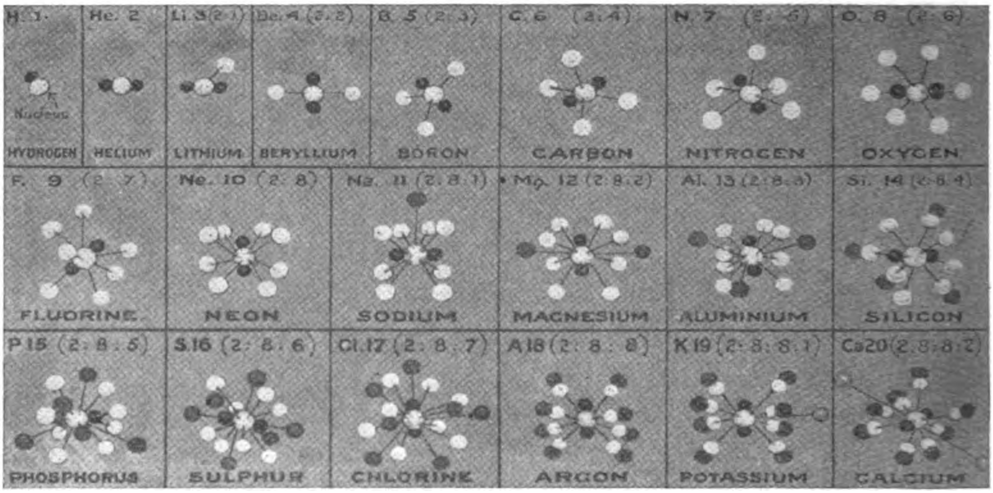
Where this unit is to be used with a tuner already using the AC tubes, care should be taken to see that the same filament lead is connected to the "B" in the tuner as in the amplifier. The fifth post from the top is connected to the "B—" and this post should connect to the post which goes to the filament and "B—" of the preceding unit. This precaution will prevent a short-circuit through the common "B—" connection. Where a separate "B" battery is used for the amplifier no such precautions need be taken.

When this amplifier is properly built and properly connected it will give very satisfactory results on a loudspeaker.



THE PANEL ARRANGEMENT FOR THE AMPLIFIER

FIGURE 6: *This picture shows the front view of the panel installed in the cabinet. The only instruments on the front are the two jacks which connect to the first and second stages of amplification and the row of binding posts at the left.*



THE PROBABLE NUMBER AND ARRANGEMENT OF ELECTRONS IN THE ATOMS OF VARIOUS ELEMENTS

FIGURE 1: *The first model shows an atom of hydrogen, which consists of a positive nucleus and only one electron; the last model shows the calcium atom, which contains a positive nucleus surrounded by twenty electrons.*

The ATOM

ARTICLE No. 2: THE NATURE OF GASES

In this article the author reveals in simple, everyday language some more of the little-known facts about the atom—that little understood particle that plays such an important part in radio—and the laws that govern electrons in the various combinations that make up the various elements.

By SIR WILLIAM BRAGG, K.B.E., D.Sc., F.R.S., M.R.I.

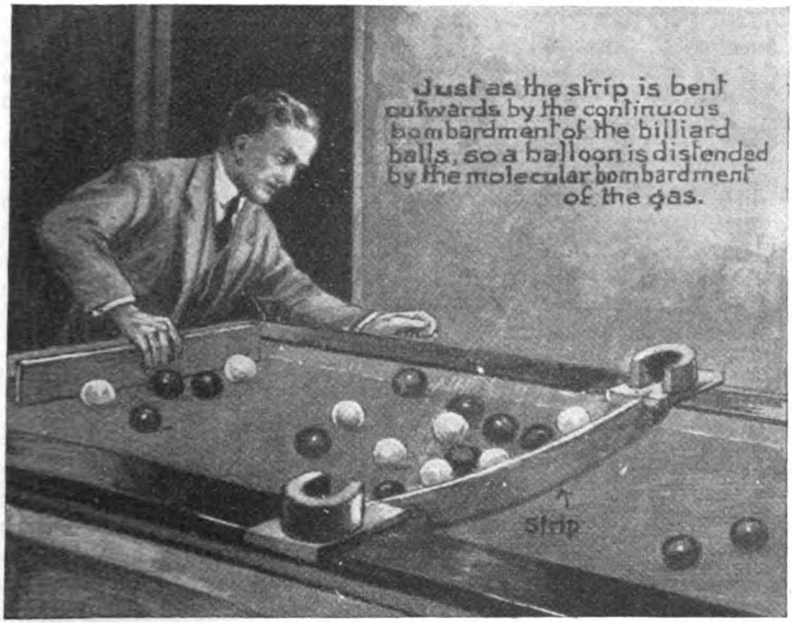
IN the first article it was shown that the behavior of the helium atom, which was expelled by the radium atom at the moment of its disintegration, necessitated a new conception of the structure of an atom.

The helium atom passes *through* the hundreds of thousands of atoms of all sorts which it may meet in its brief career. Starting at the rate of 100,000 miles a second, it travels in a straight line, until its energy is used up in the encounters with the atoms it meets. This and other effects observed in the movement make us believe that each atom is like a minute solar system, in which the sun is replaced by a nucleus charged with positive electricity, surrounded by negatively charged satellites which we call electrons. The positive charge of the atom is invariable: its amount determines the number of electrons which it can attach to itself. A "six-electron" atom, for example, has a nucleus charged with positive electricity equal to six of the standard units of electricity in nature—there is only one standard magnitude. It can attach to itself six electrons, for every electron has one standard unit of the negative electricity which is the antithesis of the positive.

The atom as a whole is electrically neutral. The behavior of the "six-electron" atom is, for all practical purposes, entirely determined by the fact that the nucleus is a "six-electron" nucleus. It is what we call carbon. When the atoms of carbon are arranged in a certain way, they form diamond; a second arrangement gives graphite, and black lead; carbon is the most important constituent of the animal body and of all organic substances, of coal, of fats, oils, petrol and a vast variety of well-known materials. But, though it plays so great a part, all its properties and uses depend on its possessing a six-electron nucleus. A "seven" or a "nine," or any other number gives totally different properties, and, in fact, makes a new substance. The former is nitrogen, and the latter fluorine.

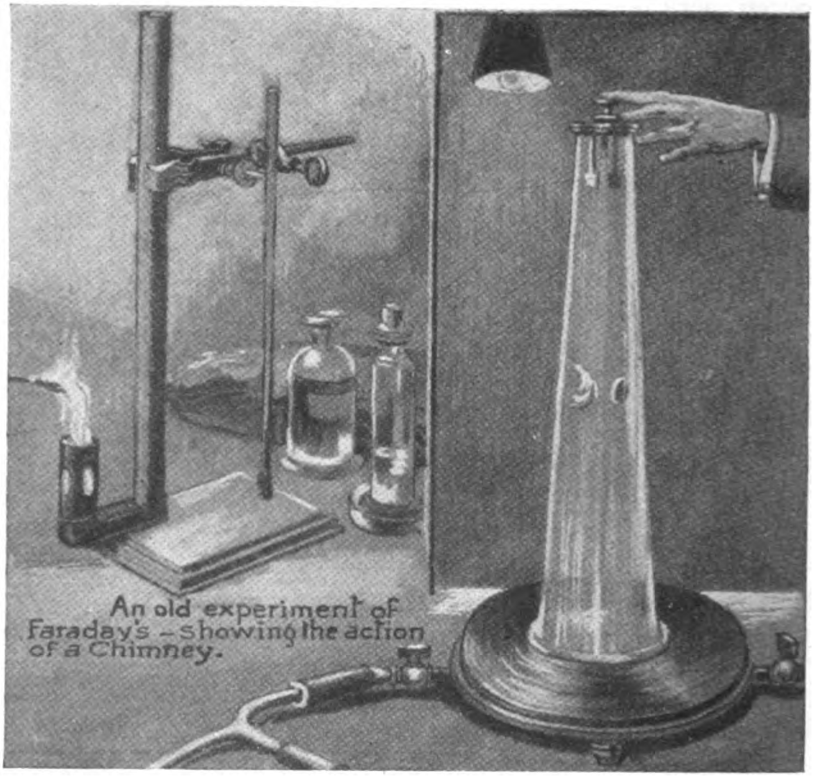
Atoms are found with almost every number of charges on the nucleus, from the "one-electron" atom which we call hydrogen, to the "ninety-two" electron, which is called uranium. Every atom has its name: a name generally given by the discoverer as indicating some special property which it possesses; or it may have been discovered so long ago that the origin of the name is obscure. Most of the names are well known and time-honored, and are not likely to be abandoned. Actually each kind of atom is identified with a certain number, as already explained; so that the number is a perfectly sufficient description. Some of the atoms have not yet been met with; for example, number 43. A few months ago there was great interest in the discovery of number 72; it is generally agreed that it shall be called "hafnium," the name being derived from the old Latin name of Copenhagen, where its existence was proved.

In the first of the figures on the opposite page a set of models is shown (Figure 1). These are to represent, roughly, a probable feature of the arrangement of the electrons in each of the first twenty atoms. Whether the electrons are in movement or not, and what is the character of any movement they possess, is for the present of no importance. The point that is meant to be illustrated is an un-


Just as the strip is bent outwards by the continuous bombardment of the billiard balls, so a balloon is distended by the molecular bombardment of the gas.
strip

HOW MOLECULES OF GAS "BOMBARD" A CONTAINER

Figure 2: *This drawing shows, by analogy, how a gas expands the silken envelope of a balloon by bombardment; the tiny molecules of gas act on the envelope separately, just as the billiard balls do, in bending the strip outward.*


An old experiment of Faraday's – Showing the action of a Chimney.

LABORATORY EXPERIMENTS THAT ILLUSTRATE PHYSICAL LAWS

FIGURES 3 *and* 4: *The figure on the left shows the action of a chimney in guiding the molecule of gas through a tube to the flame. Figure 4 (on the right) illustrates the fact that a feather and a coin, although of different sizes and weights, fall at exactly the same rates of speed in a vacuum.*

doubted arrangement in groups, to some extent concentric about the nucleus. Thus the first, hydrogen, has one electron; the second, helium, has two. These electrons are more closely associated with the nucleus than any of the others that are to be added as we go to higher numbers. The nucleus of lithium can attach three electrons to itself. Two of these are closely associated with the nucleus just like those of helium; the third is further away, and is not to be classed with the first two.

As we go along the line and add one electron after another—the positive charge on the nucleus growing steadily—the new electrons are to be classed with the third electron of lithium. The two inside members are present in all of them; but an outer shell is being formed. This goes on until the number in the new class is eight. After that a third group appears, which grows until it also has eight members; and after that appears a fourth. We need not go further, because the rules of the further formations are of a similar character, and we wish to avoid the complication of detail.

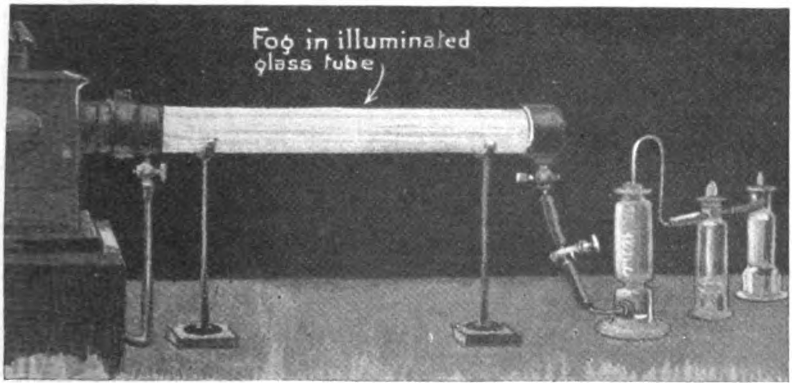
All these facts are illustrated by the models. For instance, aluminum has a "thirteen-electron" nucleus, and the thirteen electrons which it can attach to itself are so arranged that there are two close to the nucleus, eight in the next group, and three in the next.

The forces exerted by one atom on another, when the two are brought close together, are very complicated in character, and are imperfectly understood. If more were known, the models might be more exactly constructed. No doubt they depend on the way the atoms are presented to each other, just as—to take a simple example—a magnet can be made to attract another magnet according to the way their poles are brought together. We know that atoms do attach themselves to one another, and that the forces are very different for different members and arrangement of electrons, and depend on that arrangement. For example, fluorine, which has two electrons in the first group and seven in the second, has properties very similar to those of chlorine, which has two in the first, eight in the second, and seven in the third. In both cases the outside group, that which presents itself to the outside world, is an arrangement of seven.

A certain number of the atoms have singularly feeble attractions for any other atoms, whether like or unlike themselves. These are numbers 2, 10, 18, 36, 54, 86. They are, we may say, the "unsociable atoms," because they never combine with others, they take very little part in the affairs of the world. They were, in consequence, overlooked until a few years ago. The late Lord Rayleigh found that, after the oxygen had been removed from a sample of air, and every other known gas which might be contained as a small impurity, the remainder did not, as he expected, exactly resemble the pure nitrogen which he prepared in the usual ways. With the help of Ramsay he proved the existence of a new gas in the air, which was the number eighteen shown in our models. The proportion in the atmosphere is quite considerable. The air in the theater of the Royal Institution weighs about three quarters of a ton; of this about eighteen pounds is composed of the new gas. Such a proportion would easily have been discovered long ago if the new element had been willing to enter into combination with any other. The discoverers named the element "argon," the lazy one, because of its unwillingness to associate itself with other atoms. It is rather, however, unsociable than lazy; its physical movements are as quick as those of any other atoms of the same weight.

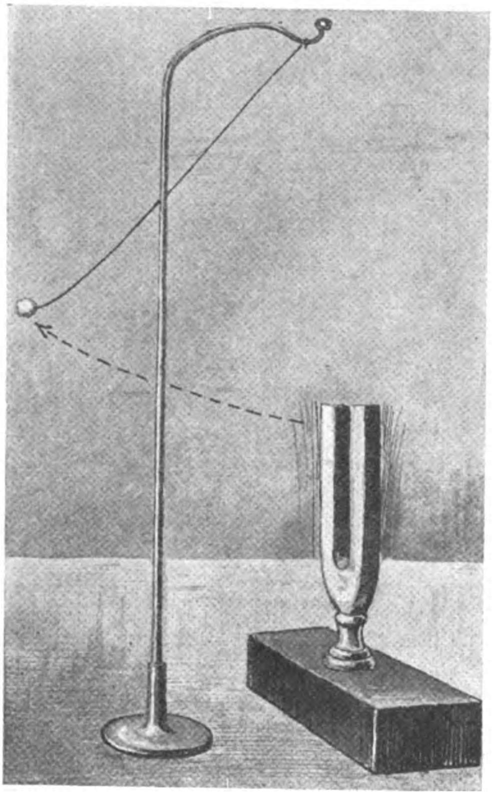
The discovery of argon was quickly followed by the discovery of others like it. The two-electron, helium, was found in certain minerals; its existence in the sun was already known. Neon (10), the "new" gas; krypton (36), the "hidden" gas; xenon (54), the "stranger," and the radium emanation (86) are all very rare.

All these are gases, which is to be expected. Their atoms are in movement, and are each on their own, there being so little tendency to associate. Only when the temperature is greatly reduced do they liquefy, especially those that are light. They are excellent examples of the nature of a gas; of the state in which



AN EXPERIMENT WITH MAN-MADE FOG

Figure 5: *A dense fog may be formed in a tube by moisture settling on the innumerable small particles in the air.*



HOW SOUND WAVES ARE PRODUCED

FIGURE 6: *This picture of a laboratory set-up shows how the atoms of a gas are set in motion by contact with vibration; a pith ball is hurled away when it comes in contact with a vibrating tuning fork.*

movement overcomes attraction. There are many other well-known substances which are usually met with as gases, oxygen, hydrogen, nitrogen, and so on. But in these cases we have examples of molecule building which will be considered more carefully later. In each case atoms have combined in pairs; and the pair forms a contented combination, somewhat unwilling to join up with other atoms, and therefore maintaining an independent existence like argon.

The properties of a gas are readily understood if its nature is borne in mind. It is convenient to take the analogy of a billiard table. For these lectures, Messrs. Burroughs and Watts were kind enough to make a special table of small size and having no pockets. A number of balls moving on the table represent the atoms of a gas-like argon; the cushions represent the walls of a containing vessel. The only defect is that the balls, when set moving, soon come to rest, whereas the atoms of the gas are always on the move. But the table and balls may still be used to illustrate the main properties of a gas. The pressure of a gas on its containing vessel is illustrated by the continual bombardment of the cushions by the moving balls; a thin strip forming a false cushion is bent outwards just as a balloon is distended by its gas (Figure 2). If, again, a loose cushion is pushed in, the balls are made to move more quickly. Just so, when the piston is driven into a cylinder, the atoms or molecules of the gas move more quickly. In other words, the gas is heated, as every one has realized who has felt the bicycle pump grow warm with use. If the gas is allowed to expand suddenly, it is chilled; so, if the false cushion is withdrawn, the balls that strike it lose some of their speed. In the same way, the hands are drawn back while catching a ball, so that the ball can be brought to rest. If damp air is allowed to expand suddenly, the chill may produce a fog. The apparatus that is shown in the figure is designed to show the effect (Figure 5). If the air is clean, though damp, the expansion produces a light mist; but if the air of the lecture-room is drawn into the tube, the expansion produces a sample of London fog.

The pressure of the atmosphere is much greater than may naturally be supposed. Its flexibility, due to the independence of the separate atoms, is so great that its massiveness is overlooked. The pressure on the exterior of the human body is more than ten tons. The body would collapse were it not that gases and liquids within are exerting the same pressure outwards, so as to counter the pressure of the air.

Pathé

The Diary of a Radio Fan

By D. R. PATTERSON

Dec. 20.—The papers say you can hear music and bedtime stories with a little box affair connected to telephones on the head, like a telephone operator. Oh, well! Just another fad.

Dec. 22.—Bill Parker says this radio stuff is good. Says he can almost distinguish the words on a set he made himself. Think I'll get one for son Gordon.

Dec. 23.—Hooked up a radio set to clothes lines tonight after Gordon had gone to bed. You have to monkey around with a little curly wire dinkus the clerk told me was a cat's something-or-other. Then you connect the clothes line to a water pipe or something, and a condenser (or was it a crystal?) has to be touched by the curly wire variocoupler. Maybe I've got it wrong.

Dec. 24.—The darned thing works! Late tonight, after Parker fixed the wires up right and Friend Wife was in bed, I heard a chap saying, in the ear phones: "This is Station BVD broadcasting—" Later on I heard some dots and dashes. It will be great sport for Gordon.

Dec. 26.—Tried all day yesterday to hear something on the radio but had no luck. Son Gordon, who has the modern idea of all children that they can do anything better than their parents, tried it. And purely by luck he got some nice music going. This should be good stuff.

June 4.—Bill Parker says the new idea of vacuum bottles instead of crystals is better, but you have to use storage tanks—or was it storage batteries? Will go over and see what his new idea works like when he gets it going, just so I can tell the young son about it. I have no interest in it myself.

June 10.—Heard some great stuff at Parker's tonight. Must get Gordon a set like Bill's. Son must be kept up-to-date.

July 12.—Tried all evening to hear something on new outfit; phoned a chap who sold it and he showed me where I'd forgotten to put the vacuum tube in place. Stayed up till three A.M. listening to dots and dashes.

July 13.—Must teach Gordon the Morse code so he can read the messages in the air. Dug up a code in the encyclopedia. Copied message I heard like this: "AXGP dnm 64k hsd mnli." Must have been some operator outside the three mile limit. Maybe I didn't get it right myself.

Aug. 29.—Had a lot of trouble on Monday—that is, Gordon did—until Bill Parker discovered it was the washing on the line. Friend Wife will have to hang the washing in the cellar.

Sept. 1.—Parker helped me to put up an aerial wire from chimney to a tree, so it won't interfere with washing any more. Now hear stations in the west but can't get southern ones.

Nov. 5.—Gordon wants to know why he can't work the set himself. Says I oughtn't to want to listen to what Hoppity Rabbit did to Phewie Skunk. I don't like fussing with the darned radio but have to get it running for the sake of the kids.

Jan. 8.—Parker says aerial is in wrong direction. Took it down and put it up on another tree. Now hear southern stations but no westerners.

Jan. 20.—Gordon is now using the old crystal set all himself, while I keep on experimenting with the big one until I get it working right for him. Heard three concerts tonight; got to bed earlier, two A.M. Willing to lose a little sleep for the sake of the children.

Mar. 3.—Got a new book which says a variable condenser is no good. Gave the old set to Gordon.

Mar. 4.—Bought a new set, regenerative variocoupler and variometers. Was telling the boys at the office how to work it, and those big words came in fine. (Memo: find out what those words mean.)

Mar. 15.—Tried for an hour to get a station; gave it up. Put set away in the attic.

Mar. 30.—Saw a good program in the paper tonight which was to be put in the air by station IOU. Some day I may dig up that set and see if it works.

April 24.—Bill Parker has a copy of Popular Radio that shows all the new radio stunts. No wonder my set wouldn't work! Bill showed me where I was wrong, and we stayed up till three A.M. tuning in different stuff.

Apr. 18.—This radio is great dope! Heard sixteen different stations tonight; heard a lecture on shoemaking and one on curing hay fever. Friend wife says you wouldn't go to those lectures in a hall. Isn't that just like a woman?

May 15.—Bought a new book which shows that all my trouble was on account of the aerial. Took it down. Building a set myself on plans in the book.

May 16.—Took the day off to finish set. Got tangled up with the coils of wire and also bust the black panel. Finally hired a young radio enthusiast to finish it for me. Didn't cost much more than a factory built set.

May 17.—Now using new set with bedspring instead of outside aerial. With a loop hung on a miniature "Stop, Look and Listen" sign can hear western and southern stations now, but not very well. No wonder the other set wouldn't work.

May 20.—This new outfit is too complicated to bother with. Gave it to Gordon and hooked up the old crystal set. No batteries to bother about.

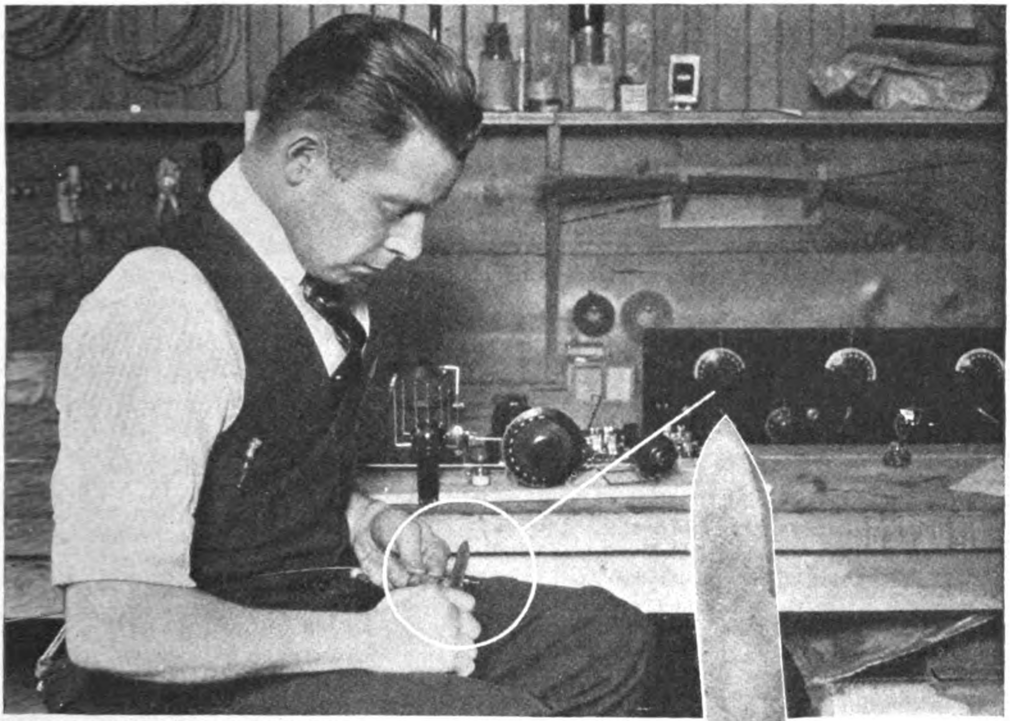
July 25.—Off the radio for life. Had the boss in to hear the thing tonight and couldn't make it work. Boss wonders why I stay off work to monkey with it. After he left, young Gordon tuned in Cuba on his set, just by chance.

Sept. 8.—The reflex is the thing! No more regenerative radio frequency for me. This new book says the sound goes in the vacuum tube and out, then dashes through it a few times more, picking up more sound each trip, with a final run through a crystal. Have to look up the prices of these sets.

Oct. 10.—Friend Wife wants to know why we didn't buy a flivver instead of spending all the cash on radio sets. No interest in science, these women.

Oct. 25.—Too much work getting new set working. Son objects to taking any more sets. I took back his old crystal set and bought him a tricycle. The crystal is the thing for me!

Handy Tools for Radio Fans: No. 6



From a photograph made for POPULAR RADIO

THE JACKKNIFE

Useful for making connections

IT is almost impossible to put up a set, install an antenna, and make connections to batteries, without the use of a knife, yet this tool is often overlooked in the radio fan's kit.

For scraping the insulation from wire that is to be used for connections and for cleaning up the ends of wires that are to be soldered, the jackknife is invaluable. It should contain one large "husky" blade and at least one other smaller blade. There are some knives that are also provided with a small screw-driver blade.

The preceding suggestions in this series were SIDE-CUTTING PLIERS, SCREW-DRIVERS, THE HYDROMETER, THE BATTERY-TESTING VOLTMETER *and* THE FILE.

"What Set Shall I Buy?"

4th Installment

For the guidance of readers who want specific and authoritative information concerning the best of the ready-made receivers that are now on the market, this feature will be published monthly until all of the receivers that have passed the tests of the Popular Radio Laboratory have been included

The Standardyne Receiver

Manufacturer's Name; Standard Radio Corporation

Model; Standardyne

Number of Tubes; five

Type of Tuning; tuned-radio-frequency with a variable-reactance control that gives the receiver practically a straight line regeneration or tendency toward oscillation curve

Type of Detector; vacuum tube

Range on Phones; 3,000 miles

Range on Loudspeaker; 3,000 miles

Cost, Complete; with cabinet, $60.00; with all accessories, $90.00 to $150.00

Antenna Recommended; antenna about room or outside antenna about 100 feet long

Kind of Tubes for R. F.; UV-199, 201-a, DV-3, DV-2

Detector Tube; same

Audio Tubes; same

Type of "A" Battery; 4½ volt dry cells for 199 or similar tubes; 6 volt storage for other tubes

Type of "B" Battery; 90 to 100 volt dry or storage "B" Battery

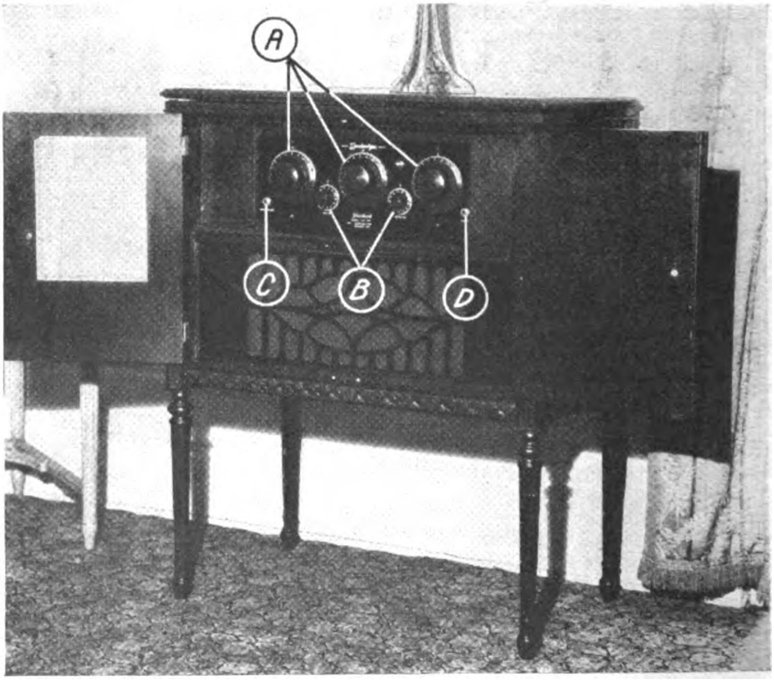
Detector "B" Voltage; 22½ to 45 volts

Wavelength Range; 190 to 575 meters

Number of Tuning Controls; 3 individual variable condensers, detector and audio on one rheostat; radio on another

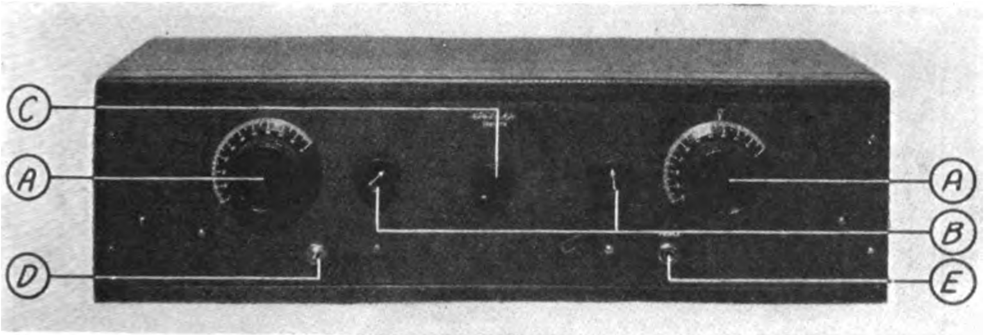
"A" Battery Current Used; 3 amperes with dry-cell tubes, 1¼ amperes with 201-a tubes

"B" Battery Current Used; 15 to 25 milliamperes, depending on tubes used



THE COMPLETE RECEIVER IN A CABINET

This picture shows the "Standardyne" receiver mounted in a cabinet that contains batteries and loudspeaker. The dials A are the three tuning coils; B are the two rheostats; C and D are the loudspeaker and phone jacks for plugging in.

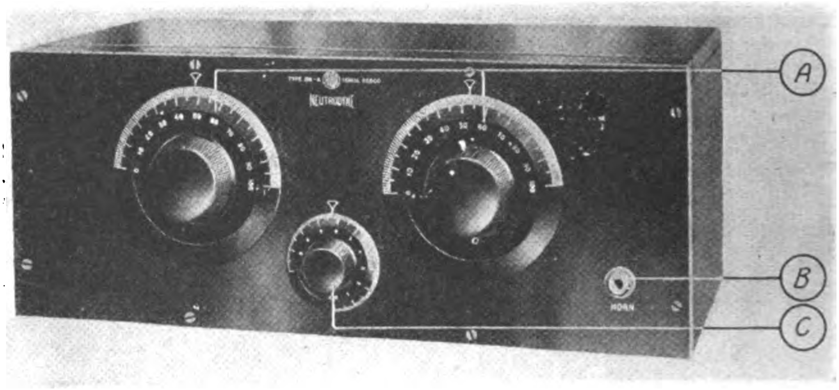


Trirdyn Receiver

Manufacturer's Name; Crosley Radio Corp.
Model Name; Trirdyn
Number of Tubes; three
Type of Tuning; tuned R. F. combined with regenerative detector, and reflex amplification
Type of Detector; vacuum tube
Range on Phones; 1,000 to 1,500 miles
Range on Loudspeaker; 1,000 to 1,500 miles
Cost Complete; $65.00
Antenna Recommended; outdoor
Kind of Tubes for R. F.; UV-201-a, C-301-a, WD-12, C-12, UV-199, or C-299
Detector Tube; UV-200, C-300, WD-12, C-12, UV-199, or C-299
Audio Tubes; UV-201-a, C-301-a, WD-12, C-12, UV-199, or C-299.
Type of "A" Battery; to suit tubes
Type of "B" Battery; 90 volts
Detector "B" Voltage; 22½ volts
Wavelength Range; 180 to 575 meters
Number of Tuning Controls; two
"A" and "B" Battery Current Used; depends on tubes used

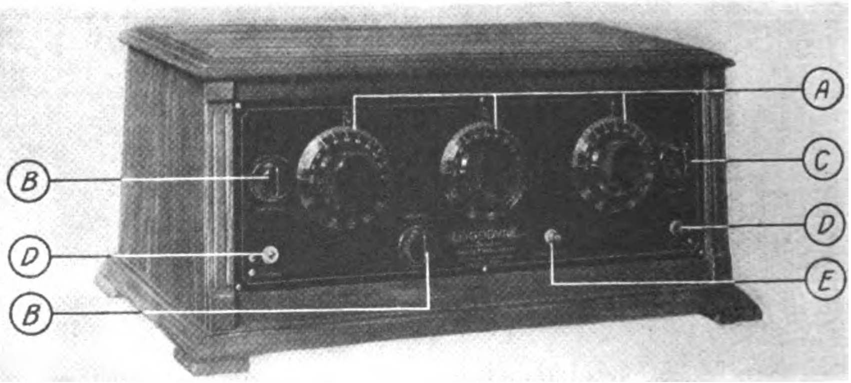
Melco Five Receiver

Manufacturer's Name; Amsco Products, Inc.
Model Name; Melco five
Number of Tubes; five
Type of Tuning; variometer-inductance
Type of Detector; vacuum tube
Range on Phones; coast to coast
Range on Loudspeaker; coast to coast
Cost; $165.00 without accessories
Antenna Recommended; 20 to 25 feet indoor or 60 to 75 feet outdoor
Kind of Tubes for R. F.; UV-201-a or C-301-a
Detector Tube; UV-201-a or C-301-a
Audio Tubes; 201-A or 301-A
Type of "A" Battery; Exide 100 amperes
Type of "B" Battery; Burgess 45-volt
Detector "B" Voltage; 45 volts
Wavelength Range; 200 to 600 meters
Number of Tuning Controls; three
"A" Battery Current Used; 1¼ amperes
"B" Battery Current Used; 10 to 15 milliamperes



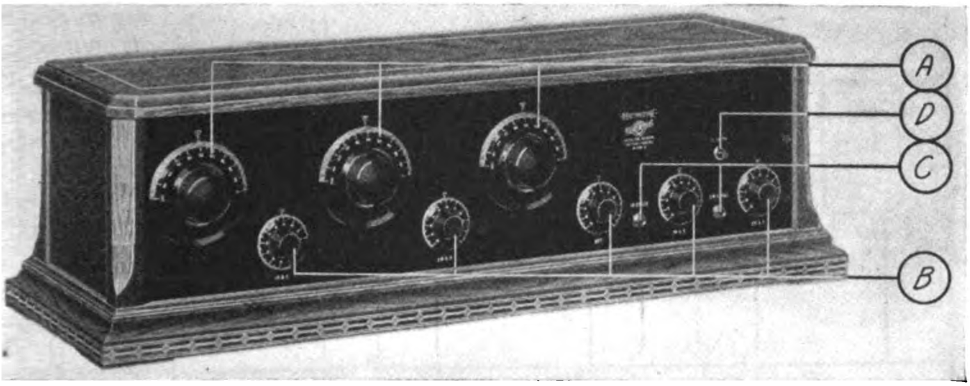
Neutro-Junior Receiver

Manufacturer's Name: F. A. D. Andrea, Inc.
Model Name; 195-A Neutro-Junior
Number of Tubes; three
Type of Tuning; neutrodyne
Type of Detector; tube
Range on Phones; 500 to 1,000 miles
Range on Loudspeaker; up to 500 miles
Cost; approximately $110.00
Antenna Recommended; single wire, 60 feet
Kind of Tubes for R. F.; UV-201-a, C-301-a
Detector Tube; UV-201-a, C-301-a, UV-200, C-300
Audio Tubes; UV-201-a, C-301-a
Type of "A" Battery; 6 volts
Type of "B" Battery; 90 volts
Detector "B" Voltage; 22½ volts
Wavelength Range; 200-600 meters
Number of Tuning Controls; three
"A" Battery Current Used; ¾ ampere
"B" Battery Current Used; approximately 10 milliamperes



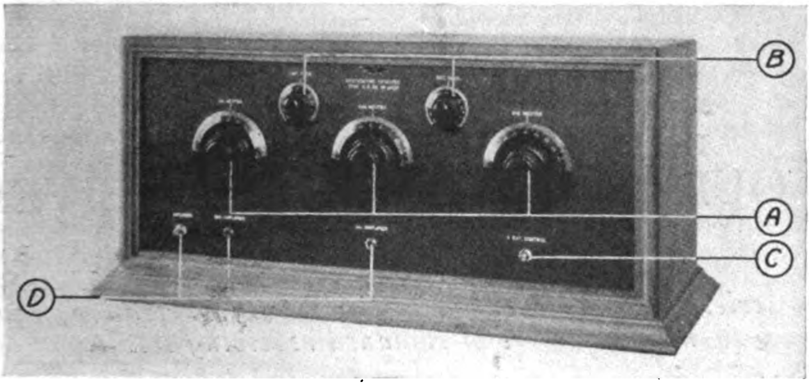
The Logodyne "Big Five"

Manufacturer's Name; Kodel Radio Corp.
Model Name; Logodyne "Big Five"
Number of Tubes; five
Type of Tuning; tuned-radio-frequency
Type of Detector; vacuum tube
Range on Phones; 1,000 miles
Range on Loudspeaker; 1,000 miles
Cost, Complete; approximately $125.00
Antenna Recommended; single wire
Kind of Tubes for R. F.; 201-a
Detector and Audio Tubes; 201-a
Type of "A" Battery; storage
Type of "B" Battery; 90 volt dry cell
Detector "B" Voltage; 22½ to 45 volts
Wavelength Range; 200 to 550 meters
Number of Tuning Controls; three
"A" Battery Current Used; 1.25 amperes
"B" Battery Current Used; 20 milliamperes



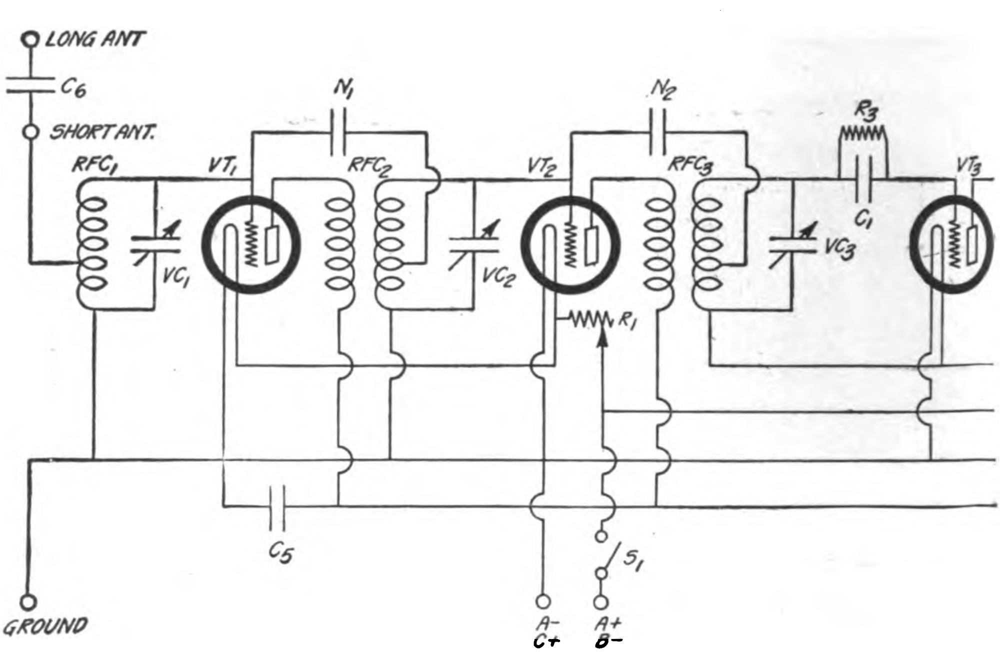
Howard Neutrodyne Receiver

Manufacturer's Name; Howard Mfg. Co., Inc.
Model; models A, B and C
Number of Tubes; five
Type of Tuning; three dial neutrodyne
Type of Detector; UV-201-a or C-301-a
Range on Phones; coast to coast
Range on Loudspeaker; coast to coast
Cost Complete; $200.00
Antenna Recommended; 50 feet single wire
Kind of Tubes for R. F.; UV-201-a or C-301-a
Detector Tube; UV-201-a or C-301-a
Audio Tubes; UV-201-a or C-301-a
Type of "A" Battery; 6-volt storage
Type of "B" Battery; 90-volt dry or storage
Detector "B" Voltage; 45 volts
Wavelength Range; 200-600 meters
Number of Tuning Controls; three
"A" Battery Current Used; 1¼ ampere
"B" Battery Current Used; 12 milliamperes



No. 100 Neutrodyne Receiver

Manufacturer's Name; Wm. J. Murdock Co.
Model Name; No. 100 Neutrodyne
Number of Tubes; five
Type of Tuning; 3 dial neutrodyne
Type of Detector; vacuum tube
Range on Phones; 3,000 miles
Range on Loudspeaker; 1,500 miles
Cost; $100.00 with loudspeaker but without batteries or tubes
Antenna Recommended; 60 to 100 feet
Kind of Tubes for R. F.; UV-201-a Radiotrons
Detector Tube; 201-a Radiotrons
Audio Tubes; UV-201-a Radiotrons
Type of "A" Battery; storage
Type of "B" Battery; regular
Detector "B" Voltage; 22½ volts
Wavelength Range; 150 to 650 meters
Number of Tuning Controls; three
"A" Battery Current Used; 1¼ amperes
"B" Battery Current Used; 10 to 15 milliamperes



THE WIRING DIAGRAM OF THE COMPLETE RECEIVER

The hook-up for the Freed-Eisemann receiver. The designating letters shown in this diagram are as follows:

RFC 1—Antenna coupling coil;
RFC 2 and RFC 3—Tuned radio-frequency coupling coils, (neutroformer);
VC1, VC2 and VC3—Variable condensers;
VT1, VT2, VT3, VT4 and VT5—UV-201-a or C-301-a vacuum tubes;
C1, C2, C3, C4 and C5—Mica fixed condensers;
R1 and R2—Filament rheostats;
S1—Battery switch;
S2—Amplifier jack switch;
R3—Grid-leak resistance;
J—Loudspeaker or phone jack;
AFT1 and AFT2—Audio-frequency amplifying transformers;
H1 and H2—Neutralizing condensers.

HOW TO GET THE MOST OUT OF

YOUR READY-MADE RECEIVER

NO. 8: THE FREED-EISEMANN RECEIVER

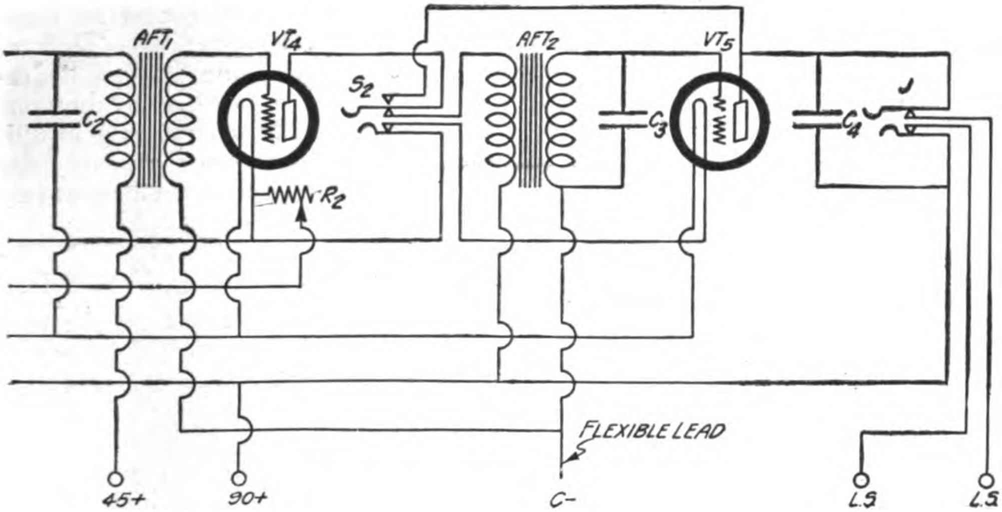
This series of articles explains the theory, operation, equipment and care of standard receiving sets

This series does not indorse the product of any manufacturer or make comparisons between receivers. The sets already described include: No. 1, the Eagle Neutrodyne; No. 2, the Radiola Superheterodyne; No. 3, the Melco Supreme; No. 4, the Crosley Trirdyn; No. 5, the De Forest Reflex; No. 6, the Atwater Kent; No. 7, the Grebe Synchrophase.

By S. GORDON TAYLOR

THE Freed-Eisemann receiver, model NR 20, is of the tuned radio-frequency type and makes use of five vacuum tubes.

The neutrodyne method of preventing oscillation in the radio-frequency amplifier is employed in this set. In view of the fact that two other receivers which employ the neutrodyne principle have already been described in this series of



articles, it will not be necessary to repeat the theory of operation nor to again describe the course of the signal through the receiver and the action of the individual parts.*

Construction of the Receiver

This receiver is designed for home use; it is not designed for use as a portable. The cabinet is of mahogany and is a massive and ornamental affair. The top raises up to permit access to the inside for the purpose of inserting the vacuum tubes and other parts. In addition there is a front door that covers the entire panel. This panel is lowered to permit access to the tuning dials and other panel controls. When the receiver is not in use the front door may be closed, thus concealing all of the tuning controls and at the same time protecting them from dust.

The receiver itself is mounted entirely on the panel and is completely assembled and wired before being placed in the cabinet. The binding posts for connections to the batteries and other parts are mounted on long shafts which extend out through holes provided in the rear wall of the cabinet; connections to these posts are made from the outside rear of the cabinet.

The Antenna and Ground

The antenna for use with this receiver may be anything from a short wire stretched along the picture moulding of one or more rooms, to a regular outdoor antenna up to 100 feet in length. For local reception a short outdoor antenna or even an indoor antenna will give results practically equal to those obtained with the larger outdoor type. For reception from distant stations, however, the longer antenna will be found best. Such an antenna is illustrated in Figure 1.

To find out which is the best ground connection in any particular location, try all that are within convenient reach of the receiver. The cold water pipe is usually best, but hot water pipes, radiators or pumps will in many cases serve equally well. If none of these are available, a pipe driven several feet into fairly moist earth will do, or a coil of copper wire suspended in the water of a well.

The antenna should be well insulated

***Readers who want this information are referred to the articles of this series which appeared in POPULAR RADIO for December 1924 and August 1925.**

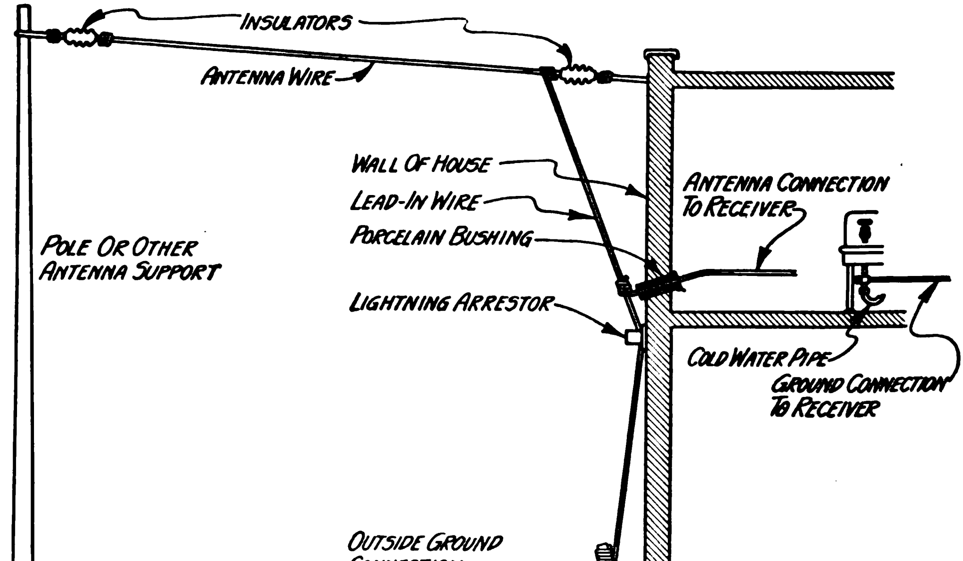
from its supports and the lead-in wire should either be a continuation of the antenna wire or else securely soldered to the antenna wire, to prevent corrosion at the joint. Before making the actual installation of the outdoor antenna it is advisable to make inquiries as to the requirements of the local rules of the fire underwriters. These require the use of a lightning arrester with an outdoor antenna and sometimes require that the arrester be installed on the outside of the house with a ground connection from the arrester to a point outside of the house. These requirements vary in different localities, but in any case the desired information may be obtained from the local fire insurance agents.

The Tubes That Are Used

The Freed-Eisemann receiver is designed for the use of the 201-a type tubes in all five sockets. These may be either UV-201-a, C-301-a or the De Forest DV2. "Soft" detector tubes, such as the UV-200 or the C-300 cannot be used, nor can power amplifier tubes such as the VT2 or 216-a be used. These limitations are due to the fact that the rheostats incorporated in the receiver have insufficient current carrying capacity for these tubes, which require comparatively high filament current.

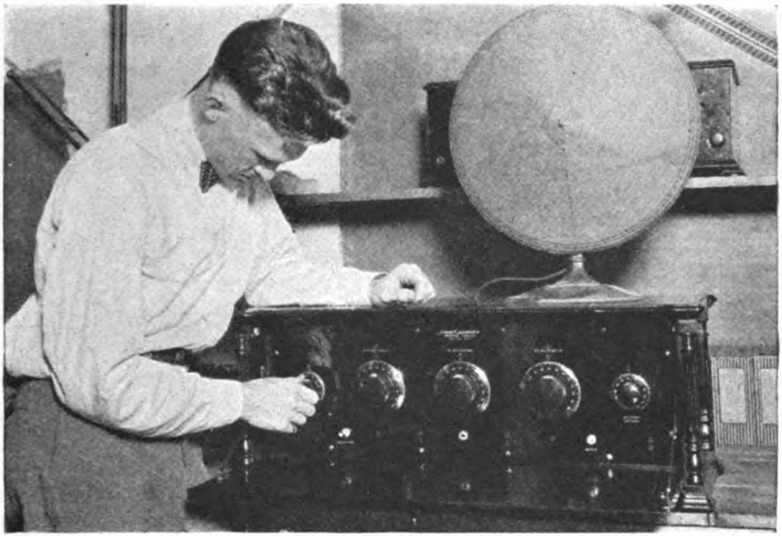
What Batteries to Use

For lighting the filaments of the vacuum tubes, a six volt storage battery is required, preferably with a capacity of not less than 60 ampere hours. The filament current consumption of the receiver is approximately 1¼ amperes an hour when all five tubes are in use. This means that, in theory, with a 60 ampere hour battery the receiver can be operated for close to 50 hours from a single charge of the battery. Actually it is not advisable to keep the battery in use until it is completely discharged, as a total dis-


INSULATORS
ANTENNA WIRE
POLE OR OTHER ANTENNA SUPPORT
WALL OF HOUSE
LEAD-IN WIRE
PORCELAIN BUSHING
LIGHTNING ARRESTOR
ANTENNA CONNECTION TO RECEIVER
COLD WATER PIPE
GROUND CONNECTION TO RECEIVER
OUTSIDE GROUND CONNECTION

HOW TO ERECT AND BRING IN YOUR ANTENNA LEAD

FIGURE 1: *This shows how the antenna should be erected and how the lead-in is attached to the antenna and anchored near the window. From the insulator outside the house the lead passes through a porcelain tube or bushing that is set in a hole bored through the window shaft.*



From a photograph made for POPULAR RADIO

THE AUTHOR EXPERIMENTING WITH THE RECEIVER

After the set had been installed in the laboratory it was carefully tested on different types of aerials and different types of loudspeakers to determine the data that has been written up in this article to enable the prospective user to get the most practical benefit from his set.

charge is harmful to the battery. With such a battery the receiver should be used only about 40 hours before recharging the battery; this means that the battery should be recharged every ten days if the receiver is used four hours a day. The advantage of using a battery with higher ampere hour capacity is therefore evident. A 100 ampere hour battery is probably the most practical size.

The storage battery requires little care other than occasional recharging. Every month or two it will be necessary to add a little distilled water to each of the three cells of the battery to keep the level of the electrolyte above the tops of the plates. It is never necessary to add acid.

A check is kept on the state of charge of the battery by means of a hydrometer. This little instrument shows the specific gravity of the electrolyte and therefore indicates the amount of charge in the battery because the specific gravity fluctuates in a known proportion with the charge and discharge of the battery. When the battery is fully charged the hydrometer should read approximately 1,285, and will drop to about 1,150 when the battery is fully discharged. The state of charge should always be kept between maximum and 1,185 for best results and prolonged life of the battery.

To provide the high voltage plate supply "B" batteries are necessary and may be of either the dry-cell or the storage type. The first cost of the former is lower but the storage batteries will be the cheapest in the long run, because instead of throwing them away when they become run down, they can be recharged for a few cents. Thus the life of storage "B" batteries is figured in years rather than weeks or months.

If dry-cell "B" batteries are used they should be either the "large" size or the extra large "heavy duty" type. The "heavy duty" type are more economical as shown in the accompanying tabulation. While their first cost is some higher, their life is much greater.

In any event, the total required "B" battery voltage is 90. In the case of dry-cell batteries this will mean two of the 45 volt blocks while in the case of the storage "B" batteries, which are usually made in 24 volt blocks, four will be needed. In this latter case the total voltage will be approximately 96, which is close enough.

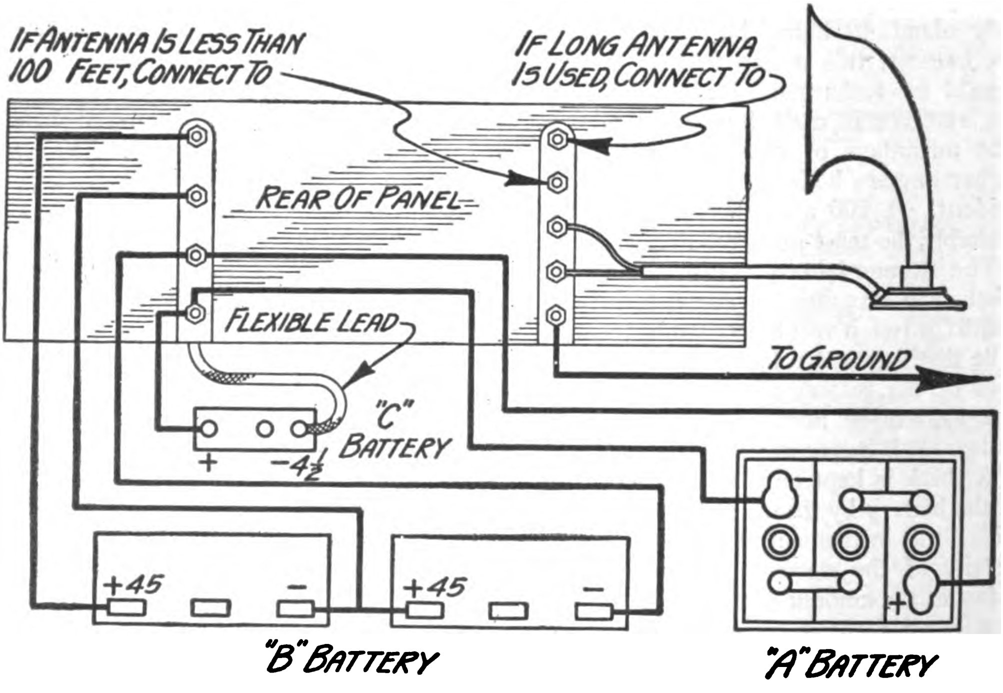
Some owners may wish to equip their receivers with a "B" battery eliminator in place of the "B" batteries. In such a case the eliminator should be purchased with the understanding that the price will be refunded if the eliminator fails to function properly during an actual trial at the home of the purchaser.

Provision is also made for the use of a so called "C" battery. This is a small dry-cell battery of 4½ volts and is used to provide the proper grid bias to the audio amplifier tubes, thus serving two most useful purposes: *First,* by maintaining the tube at the proper bias, which tends to improve tone quality and volume; *Second,* by prolonging the life of the "B" batteries, because the "B" battery current drain is reduced through the action of the "C" battery. The current drain on the "C" battery itself is almost zero and its life is therefore great —usually somewhere in the neighborhood of a year. The economy effected through the use of a "C" battery with the Freed-Eisemann receiver is shown in the accompanying tables.

How to Operate the Receiver

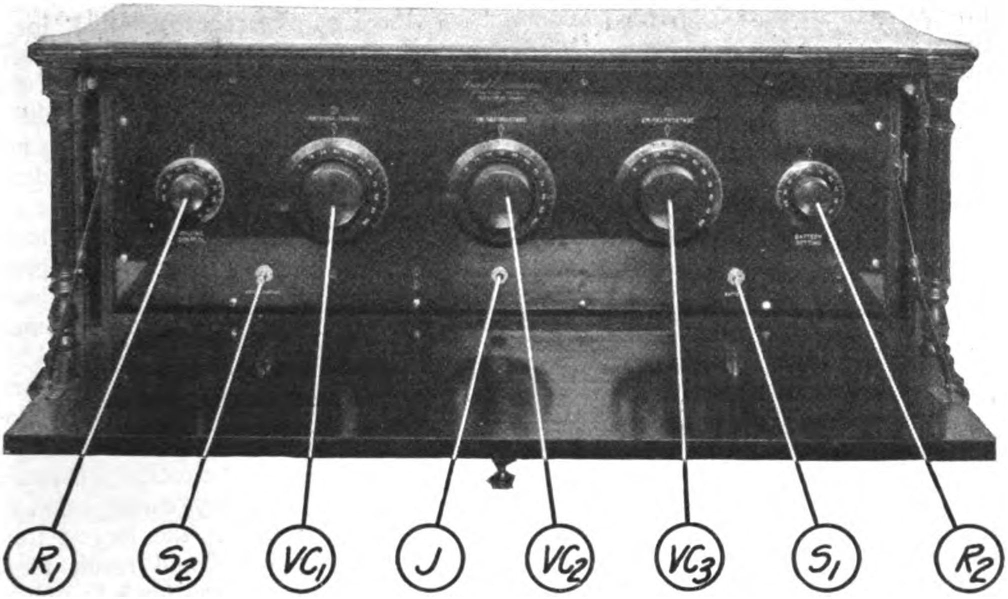
In putting the receiver into operation, connections are first made from the receiver to the antenna, ground, batteries and loudspeaker as shown in Figure 2. Be sure that connections are made exactly as shown, otherwise there will be trouble — especially if the "A" battery connections from the receiver are connected to the "B" battery instead of the "A" battery. The penalty may be one or more tubes ruined.

The filament supply current from the "A" battery is then turned on. This is accomplished by first pulling out the



THE BATTERY HOOK-UP

Figure 2: *How to connect the "A," "B" and "C" batteries to the rear of the receiver. Check up before actually using the set to make positive that you have the terminals connected exactly as shown in this diagram; then you will have no trouble with burned out tubes.*



THE PANEL VIEW OF THE RECEIVER

This picture shows the set with the front flap let down as in operation. The three principal controls are VC1, VC2 and VC3 while the rheostats R1 and R2 control the volume and quality.

knob of the battery switch in the lower right hand corner of the panel, and then turning the knobs of the two rheostats in a clockwise direction to about 40 on their dials. Now insert each of the five tubes in the first socket to make sure each lights properly.

The next step is to insert the five tubes in their proper sockets. Place them in their sockets so that the pin on the side of the tube slips down in the slot provided in the side of the socket. Then press down as far as possible and turn tube to the right as far as it will go. Thus it is securely locked in place. The rheostat knobs are then turned up to about 70.

Now the tubes should all light up, provided the knob of the "amplification" switch is pulled out, and all is in readiness to tune in the broadcasting stations. If the "amplification" knob is in only four of the tubes will light. By referring to the chart near the end of this article the approximate settings of the three large dials for a number of broadcasting stations will be found. These readings were made with the receiver shown at the beginning of this article and should correspond very closely with those of any other Freed-Eisemann receiver of this type. At least this is true of the settings of the second and third dials. The setting of the first will vary according to the antenna used.

It is advisable to first try tuning in a local station which is known to be "on the air" at the time. Find its dial settings on the chart, or the dial settings of another station operating on the same or near wavelength. When it is heard readjust each of the three dials until the greatest volume of sound is obtained. This setting will be the proper one for that station. If the station is not heard at all, even after considerable "feeling around" with the dials, it is evidence that something is wrong in the connections to the batteries, or in the tubes, and they should be checked over carefully.

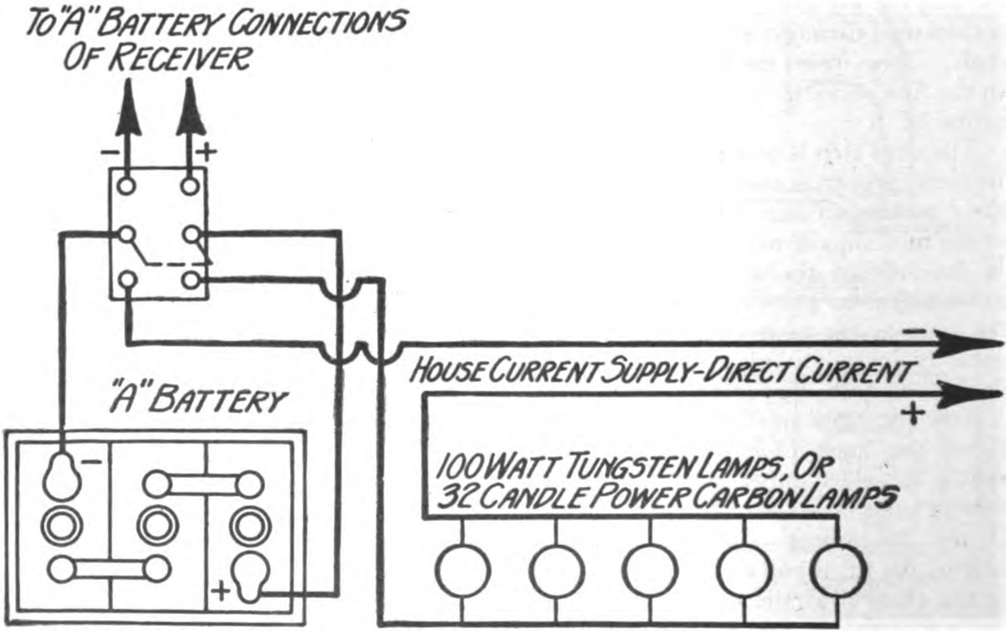
Assuming that the first station has been successfully tuned in, it is well to repeat the operation on a number of stations until the method of tuning becomes familiar. Be sure and keep a record of the dial settings at which each station is tuned in so that the same station may be tuned in again if desired, without the necessity for hunting around.

Now for a little investigation of the other controls—and a word or two of advice regarding them.

Under ordinary conditions this receiver will deliver more than ample volume of sound in the case of reception from local stations. If it is operated at full blast on the locals the tone quality will be sacrificed because the average loudspeaker cannot handle such volume satisfactorily, especially if it be operated in a small room with the acoustic qualities of the average room. Secondly too great volume is uncomfortable to the ear of those who may not be used to listening to the receiver.

The upkeep cost of the receiver can be greatly reduced by keeping the volume at a point where it is comfortably audible. In the case of local reception this is accomplished by pushing the "amplification" knob all the way in, or by turning the "volume control" dial in an anti-clockwise direction until the volume is reduced to the proper point. By following the former plan the last tube is automatically cut out of the circuit and its filament extinguished. The drain through the rheostat (R2) is thus reduced and this rheostat should be turned back (anti-clockwise) about 20 degrees on its dial. The best plan for ordinary use, however, is to leave the "amplification" knob pulled out and to control the volume by means of the volume control dial. This provides a smooth regulation of volume to just the degree desired and results in just as economical operation so far as "B" battery consumption is concerned—and this is the largest item of upkeep cost—as would result from using the "amplification" knob to reduce the volume.

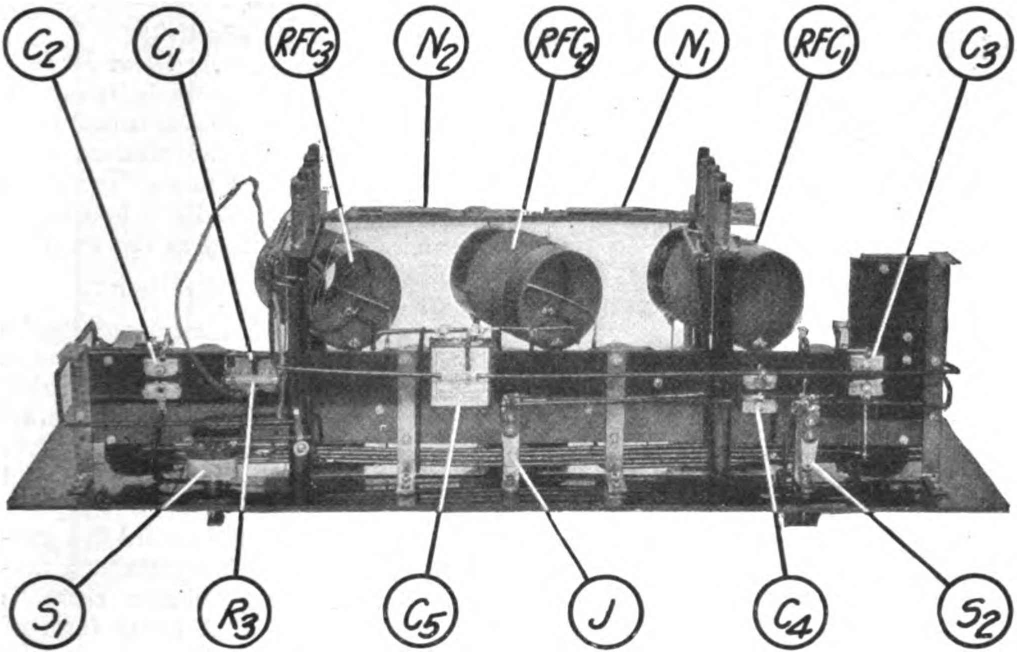
When the receiver is to be turned off it is necessary only to push in the knob marked "battery." The rheostats may be left in their regular operating position



To "A" Battery Connections Of Receiver
−
+
"A" Battery
−
+
House Current Supply-Direct Current
−
+
100 Watt Tungsten Lamps, Or 32 Candle Power Carbon Lamps

HOW TO CHARGE THE BATTERIES WITH DIRECT CURRENT

This diagram shows the proper connections for charging the storage "A" battery from 110 volt direct-current lighting lines. If you have alternating current in your home, the battery should be connected as shown in any of the preceding articles of this series.



VIEW OF THE RECEIVER FROM UNDERNEATH

This picture gives the general construction features of the Freed-Eisemann Neutrodyne receiver as viewed from below. The mounting and spacing of the coils are clearly shown as well as the method of supporting the sub-panel.

because the battery switch cuts off the entire receiver from the "A" battery circuit. Also, when the "A" battery is disconnected by means of this switch the "B" batteries are in effect cut off also, as no current can flow from the "B" battery unless the tube filaments are lighted.

The loudspeaker may be connected to a phone plug and plugged into the jack at the center of the lower edge of the panel, or it may be connected without a plug to the two binding posts that are provided for this purpose at the back of the receiver. Results are the same in either case. If desired, the headphones may be plugged into the jack whether or not the loudspeaker is connected at the back of the receiver. This is a convenience as it is sometimes desirable to use headphones in tuning in distant stations. When this is done, however, the "amplification" knob should be pushed all the way in and the "volume control" knob will probably have to be turned back somewhat to reduce the volume to a comfortable degree for use with the headphones.

In any case the two rheostat dials (R1 and R2) should be kept at as low a setting as possible, consistent with good volume.

In this way the lives of both the "B" batteries and the vacuum tube filaments will be greatly prolonged and the "A" battery will give somewhat longer service on a single charge, although this last is not important if the owner has a battery charger.

Another item that effects economy of operation is the little "C" battery.

While this battery is small and lasts for a long time its influence on the entire receiver is marked. It affects tone quality, volume and "B" battery life materially. The accompanying table showing the approximate life of "B" batteries demonstrates the effect of the "C" battery on the economical operation of the receiver. It will be noted that the life of the "B" batteries increases with increased voltage of the "C" battery; therefore it is most economical to use the full 4½ volts of the "C" battery. On the other hand the best tone quality is frequently obtained with only 1½ or possibly 3 volts of "C" battery. It is further up to the owner to experiment a little to determine whether 1½, 3 or 4½ volts of "C" battery give the most satisfactory results. Indeed the tone quality without any "C" battery at all may prove more desirable than the greater volume and economy obtained when the "C" battery is used.

Selectivity

When an antenna 100 feet in length is used, and is connected to the binding post at the back of the receiver marked "short antenna," it may be found that two stations separated less than 10 meters apart in wavelength will interfere with each other, especially if one is a powerful local station. In that case the antenna should be connected to the "long antenna" binding post. Thus connected, there will be ample selectivity.

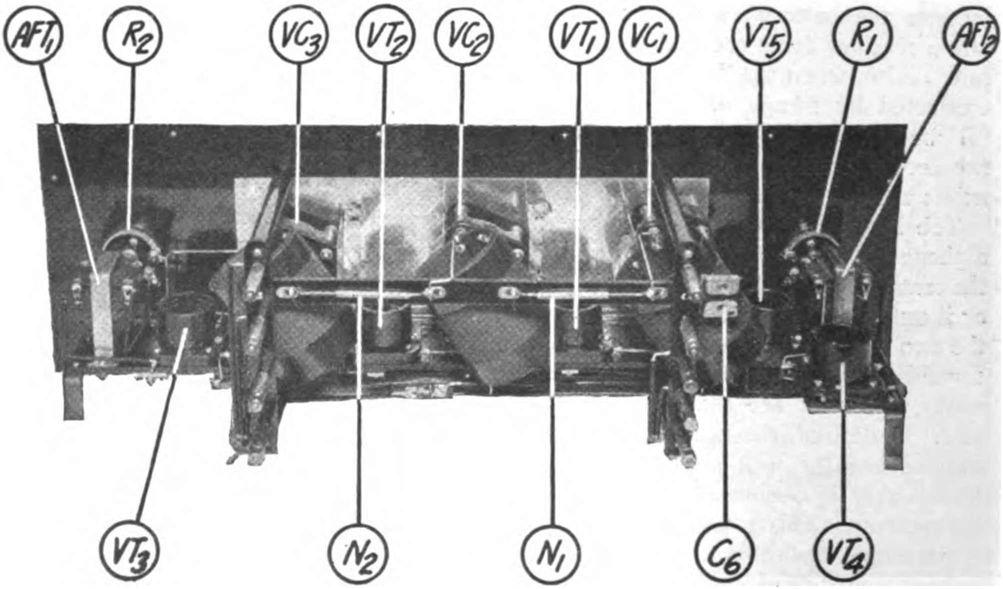
If the antenna be only 60 or 70 feet in length there will probably never be occasion to use the "long antenna" connection. Best results are obtained with the antenna connected to the "short antenna" terminal, provided it is found that selectivity is satisfactory in this case.

Charting the Receiver

Under the head of "How to operate the receiver" it was suggested that a record of the dial settings for each broadcasting station be kept, in order that the same stations may be tuned in again at will without the necessity of hunting around for them.

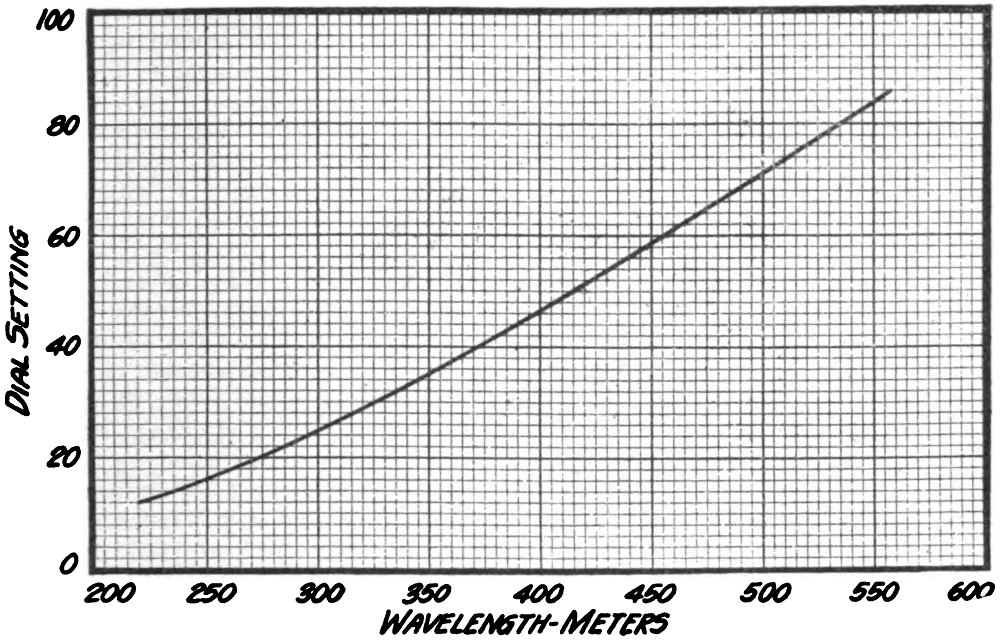
It is well to keep this record in a convenient form so that it constitutes a tuning chart. An approximate chart is shown on page 253. A better form of record, however, is one which lists the actual settings of each of the three dials, as the settings may be different.

It is advisable to jot down the settings



VIEW OF THE SET FROM THE REAR

In this picture the reader may clearly see the method of shielding the three tuning units, VC1, VC2 and VC3 and also the arrangement of the sockets and the transformers, which are mounted directly upon the top of the sub-panel. The designations of the various parts are the same as shown in the other diagrams, in the list of parts and in the text.



A TUNING CHART FOR THE RECEIVER

This gives the approximate setting for the three dials, VC1, VC2 and VC3 for tuning in the various wavelengths used in broadcasting. The first dial setting may be a little higher or a little lower than shown in this curve on account of the varying lengths of antenna that may be used with the receiver; however, the setting given above will be approximate for all three dials.

APPROXIMATE "B" BATTERY LIFE OF THE FREED-EISEMANN NR 20 RECEIVER

AVERAGE HOURS USE PER DAY	"LARGE" BATTERIES			"HEAVY DUTY" BATTERIES		
	2 hours	*3 hours*	*4 hours*	*2 hours*	*3 hours*	*4 hours*
No. "C" battery..........	68 days	38 days	20 days	147 days	84 days	52 days
1½ volt "C"...........	81 "	46 "	26 "	164 "	96 "	60 "
3 volt "C".............	91 "	52 "	31 "	179 "	107 "	68 "
4½ volt "C"...........	107 "	63 "	39 "	203 "	123 "	81 "

Measurements made with 90 volts of "B" battery, varying "C" battery voltage from 0 to 4½, "amplification" switch pulled out and both rheostats set at 70.

Same conditions as in Table 1 except with the "Amplification" switch pushed in.

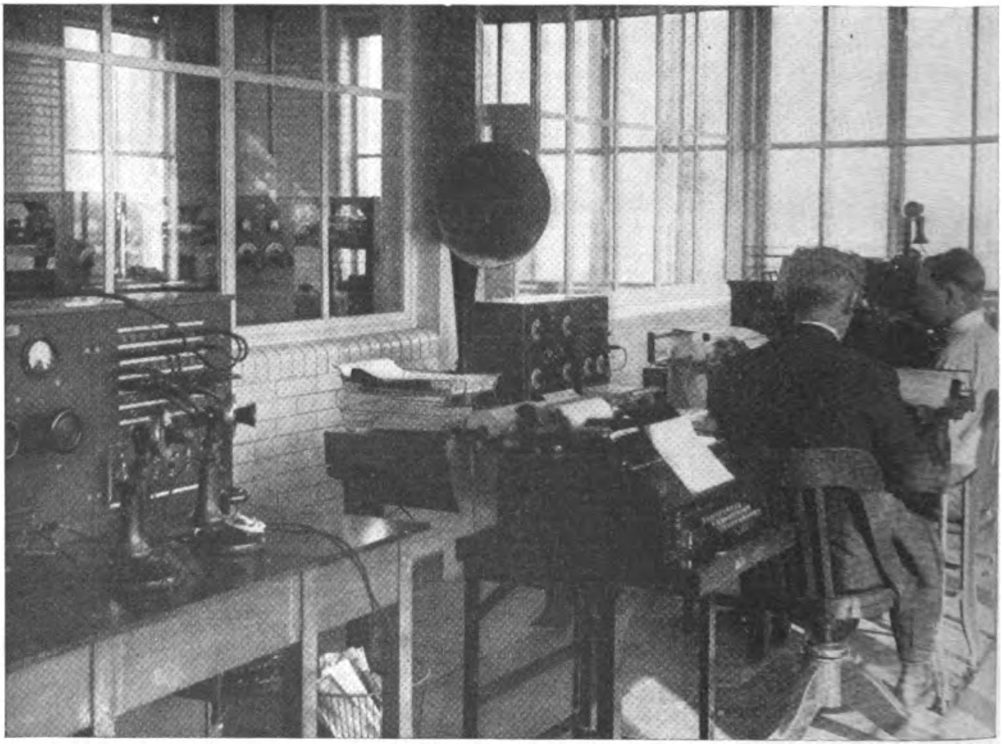
AVERAGE HOURS USE PER DAY	"LARGE" BATTERIES			"HEAVY DUTY" BATTERIES		
	2 hours	*3 hours*	*4 hours*	*2 hours*	*3 hours*	*4 hours*
No. "C" battery..........	99 days	59 days	34 days	190 days	114 days	73 days
1½ volt "C"...........	107 "	63 "	39 "	203 "	123 "	81 "
3 volt "C".............	115 "	69 "	43 "	215 "	130 "	88 "
4½ volt "C"...........	130 "	77 "	51 "	237 "	148 "	100 "

Inasmuch as the cost of "B" battery replacement is practically the entire upkeep cost of the receiver, the above tables will be of interest. The conclusion to be drawn from the tables is: To attain maximum economy, use 4½ volts of "C" battery and keep the "amplification" switch pushed in wherever this will provide sufficient volume. Also, don't start the receiver going early each evening and leave it going until bedtime unless someone is actually listening.

for each station as it is tuned in for the first time. After this has been done for a few evenings a new record should be made listing all the stations that have been recorded in some convenient order. This may take the form of a list arranged alphabetically according to station calls, or it may list the stations in the order of their wavelengths with the highest wavelength stations first. If one is not familiar with the wavelengths of the different stations, or if someone other than the maker of the record will have occasion to use it, the alphabetical arrangement will probably be best; one can easily determine which form is most suitable to his needs.

After this list has been made up it will need to be revised occasionally as new stations are tuned in for the first time, in order that the dial settings of these new stations may be entered in their proper place on the record.

The important item is to note the dial settings for every station received. Otherwise, when it is desired to listen in on the program of one particular station, several minutes may be spent in trying to locate it on the dials. This in itself does not seem a serious matter but every operator of a receiver knows the embarrassment of having to "fish around" in front of company, when one of the guests asks to hear some particular distant station. If the operator can, by referring to his tuning chart, set the dials immediately for the desired station it is much more pleasant for everyone concerned.



United

A UNIQUE USE OF RADIO IN THE BUSINESS OFFICE

Henry Ford maintains the largest private radio system in the country. His station at Dearborn, Mich., is in constant communication with six of his plants and his four lake ships. Communicating in private code, Ford is said to be able to save large sums yearly. In each of his stations are installed electric typewriters which transmit the messages to other reproducing typewriters in the various plants.

Call Letters That Have a Past

By LAWRENCE A. CORRIDON

Call letters that were originally assigned to ships that have met disaster are seldom re-assigned to other ships, in deference to the superstitions of seamen. They are, however, now assigned to broadcasting stations. For example:

KJS, now assigned to the Bible Institute of Los Angeles, was formerly used by the steamer *North Star* in transmitting an important message when on a foggy morning in August, 1919, a call for immediate assistance was sent out by the radio operator of the vessel. Radio played an important rôle in the rescue of all of the 348 persons on board.

WSB, now assigned to the station of the *Atlanta Journal*, was formerly assigned to the steamer *Francis H. Leggett* which foundered off the Oregon coast on September 18, 1914, with 67 persons on board, two of whom were lost. After this wreck the call signal was re-assigned to the steamer *Firwood* which burned off the coast of Peru on December 18, 1919, with 28 persons on board, none of whom were lost.

WHN, now used by the station of Loew's Theatre, New York City, was at one time assigned to the steamer *Hanalei* which was wrecked. It was later used by the steamer *Santa Isabel* which was sold to citizens of Chile. When a vessel is sold to a foreign country, the country to which it is sold assigns its own letters to the vessel's station.

KLZ, Reynolds Radio Co., Denver, Col., was the call of the steamer *Speedwell* in 1920. KLZ and SOS were an important combination of signals on September 29 of that year when the *Speedwell* was caught in a tropical hurricane in the Gulf of Mexico. This storm was so severe that after the distress call and position of the vessel were sent out the engine room became flooded, the dynamo ceased to work and the sea carried away the whole after-deck, taking with it the storage batteries which were necessary to operate the radio station. This catastrophe caused the loss of nine lives, including the captain, mate, and two women passengers, out of 25 persons on board.

KGB, now assigned to the *Tacoma Daily Ledger*, was at one time used by the steam screw *D. N. Luckenbach* which was sunk by a submarine about 100 miles off the French coast on December 27, 1917.

WGR, Federal Telephone Manufacturing Co., Buffalo, N. Y., was used by the passenger steamer *Governor* prior to its assignment to the broadcasting station. The *Governor* was sunk in a collision with the freighter *West Hartland* in April, 1921. Eight lives were lost. No doubt some old-time operators recollect when WGR was heard up and down the Pacific coast.

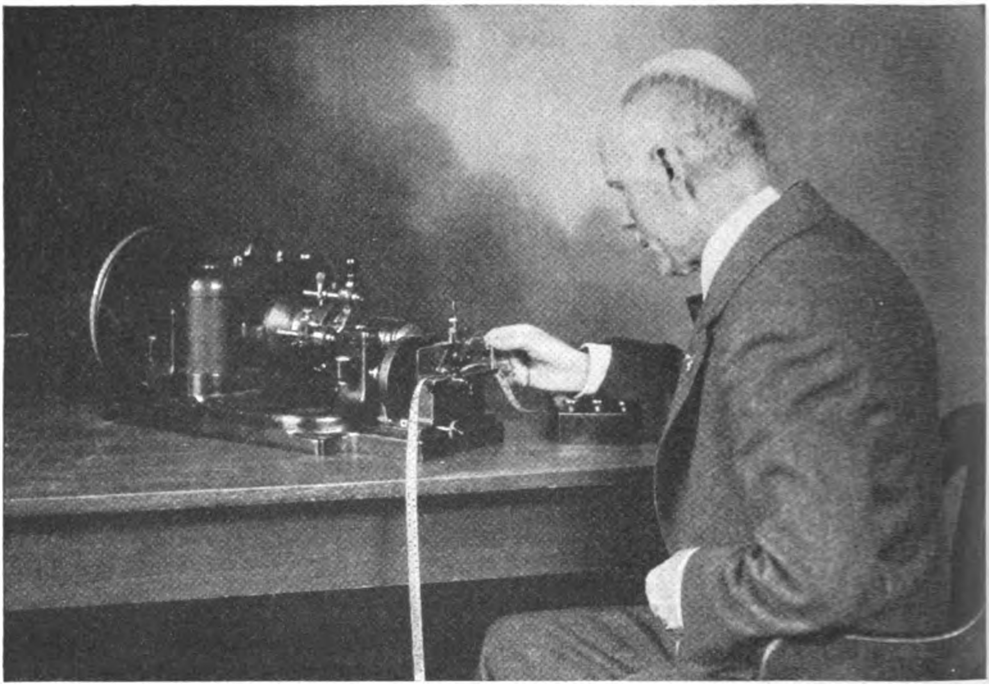
WWJ was once the call of the steamer *Peru*; it is now used by the *Detroit News* station. The *Peru* was transferred to the French flag, causing the cancellation of the call letters of the United States.

KLS, now assigned to the *Oakland Tribune*, was formerly assigned to the steamer *Kermanshah* which was transferred to the Hungarian flag.

KNX, *Los Angeles Evening Express*, was formerly used by the vessel *Susana* which was sold to citizens of Italy.

KOB, New Mexico College of Agriculture and Mechanic Arts, State College, New Mexico, was used by the steamer *Princess Anne* up to the time she stranded on Rockaway Shoals, Long Island, February 6, 1920, with 106 persons on board none of whom were lost. The *Princess* broke in two and the cargo, valued at $500,000, was practically a total loss.

KRE, *Berkeley Gazette*, Berkeley, Cal., was at one time assigned to the steam screw *Florence H.* which was blown up by an internal explosion in Quiberon Bay, France, April 17, 1918, causing the loss of 45 lives out of 77 on board.



S. R. Winters

INVENTIONS BY PUBLIC OFFICIALS MAY BECOME PUBLIC PROPERTY

The value of stock in radio enterprises that are based upon inventions and patents of men who were in the Government's employ are vitally affected by the recent court decision against Major General George O. Squier, whose "wired wireless" patents have been declared public property.

Riding to Riches by Radio

PART II

How much are the radio stocks that you own—or that you are thinking of buying—really worth? On what factors do their values depend? What is their value likely to be? In this series of two articles the author points out some of the points that every investor or prospective investor should consider before he buys.

By RALPH E. RENAUD

THE quickest way is to purchase the offered certificates, take them to your bank and ask how much they will lend you on them. But this is expensive and may subject you to insult. On the surface, at least, the proper examination of radio stocks does not differ from that suitable to any proposed investment. Perhaps the Golden Rule is: Don't believe the salesman. After that the first consideration should be the general financial position of the company. This includes the average earnings over a reasonable period, the progression of earnings in proportion to the outstanding capital, the current asset position, the latest available balance sheet and the relation of the funded debt to the capital stock. Then there is the question of management—how much brains, how much honesty and what sort of reputations are back of the enterprise? Marketability is also a factor in the radio field where changes have been so rapid.

Inventory is an item decidedly worth considering. A company which manufactures more sets than it can sell is to be avoided. These extra sets, above the prevailing market, may be carried as surplus or current assets, but they almost invariably mean loss. The only way to move such current assets is through sales, and in view of the fact that sales failure caused the accumulation the prospect is usually and obviously pretty poor. Perhaps nothing except yesterday's newspaper becomes obsolete more quickly than today's radio set. Even eggs keep better in storage.

When you have settled all these points to your satisfaction and are about to reach down into your pocket, stop one moment more. Consider the patent aspect of the stock. Ask yourself these questions:

1. What patents does the company control or under what patents are they licensed?
2. How basic are these patents?
3. Is the company equipped to conduct scientific research and thus build up its patent structure?
4. Am I about to buy a radio patent infringement suit?

Don't flatter yourself that you will ever be able to answer all these questions definitely or even approximately. The radio experts themselves, the boys who get a hundred dollars a day to contradict each other on the witness stand, can't answer them. The courts thus far have spoken obscurely and with many voices. Candidly, the patent situation is a mess.

But unfortunately for the buyer of radio stocks this patent situation must govern the future of his investment for two reasons. A patent is the most convenient nozzle in the world through which to pour water into a stock. And the patents under which any company operates may turn out any minute to be valueless or void. Nevertheless, in this labyrinth of patent litigation there are certain signposts which may serve to guide the investor toward peace and profit.

For the layman to grasp even the first syllable of the patent crossword puzzle it is necessary to go back a little way for a running start. Before the United States entered the war wireless communication in this country was controlled chiefly by the Marconi Company, a British concern. The Marconi Company, it is claimed, could not give efficient service because of faulty apparatus at both ends. It used the Fleming, or two electrode tube, but required to perfect its service at least two things which it never succeeded in getting—a three electrode vacuum tube, based on De Forest patents then controlled by the American Telephone and Telegraph Company, and the Alexanderson alternator, developed and controlled by the General Electric Company.

When the United States entered the war the government took over the Marconi stations and appealed to all manufacturers to disregard patent rights for the period of the conflict. Under the government guarantee of protection efficient radio apparatus was manufactured and many improvements perfected. All patents were, in effect, scrambled, and to this day they have never been satisfactorily unscrambled.

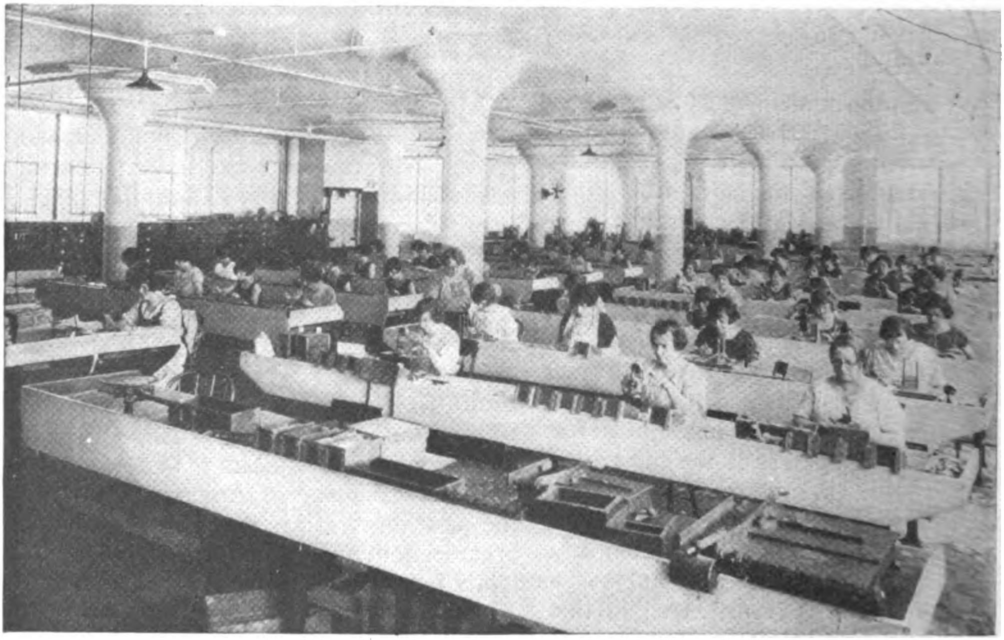
After the war the British Marconi Company naturally sought to buy the rights to the Alexanderson alternator. Their advances were smiled upon. At this juncture Admiral Bullard stepped in with another patriotic appeal to the General Electric Company not to make it possible for American radio communication to fall wholly into the hand of foreign interests.

That appeal was the genesis of the Radio Corporation of America, the child of the General Electric. In 1919 all rights and physical assets of the Marconi Wireless Company of America passed to the new corporation, a strictly American organization, which thus started with control of both the Marconi and General Electric patents. Within two years thereafter, in one way or another, it acquired the radio patent rights of the American Telephone and Telegraph, the Wireless Specialty Apparatus, the Federal Telegraph Company, the Western Electric Company, the United Fruit Company, the Radio Engineering Company of New York, and the Westinghouse Electric and Manufacturing Company which, as far back as 1920, had developed radio receiving sets but couldn't sell them because the Radio Corporation controlled the vacuum tubes.

The chief elements in this combination, of course, are the General Electric, Westinghouse and the American Telephone & Telegraph Co. Agreements of the Radio Corporation with the General Electric run to 1947, with Westinghouse to 1945 and with A. T. & T. only until 1929. Under these agreements the Radio Corporation of America accepts 60 percent of its manufactures exclusively from General Electric and 40 percent from Westinghouse. Through its various connections it is said to control the rights to something like 2,000 patents, among them the highly important Armstrong Regenerator and the Fessenden Heterodyne.

Anyone might think all this consolidation, as in the case of the steel industry, might have tended to clarify and stabilize conditions. Far from it. Despite the fact that the Radio Corporation controls 2,000 patents there are thousands more which it does not control And always there are new ones. At this moment 2,247 radio patents are pending. In addition there are all the government patents, many foreign patents and the German patents seized during the war.

The legal confusion may be gauged by the present anomalous position of the Armstrong regenerative system, a basic circuit used in the bulk of modern sets. Lee De Forest has attacked it repeatedly as an infringement on prior patents of his own. One court has decided for the Radio Corporation. Another court in a different district has held for De Forest. The Court of Appeals has ruled for Radio Corporation and De Forest is attacking on another angle in still a different court.



From a photograph made for POPULAR RADIO

A COMPANY THAT PLAYED A CONSPICUOUS PART ON THE CURB

During the first four months of this year (1925) the stock values of the Dubilier Condenser & Radio Corporation (one room in whose factory is pictured above) fluctuated between 12⅞ and 35¼. Stocks in other companies varied between 2 and 17¾. How may the causes be ascertained—and anticipated?

It will be fully two years before the United States has adjudicated the main patents in dispute. Big issues in the radio industry are at stake. Radio Corporation, for example, is suing Hazeltine on the ground that the neutrodyne is an infringement on the Rice and Hartley patents which are held the pioneer inventions in the field of controlled regeneration. The Alexanderson tuned-radio-frequency is just about to be litigated. In fact, there are now approximately twenty big radio patent suits of which six are of the most vital importance.

The recent decision against Major General George O. Squier, refusing him the fruits of his wired wireless invention, largely because it was perfected through the expenditure of government funds, has also precipitated the fat into the fire with a sickening sizzle. Every radio inventor who was in public service, during the war, and there were many, now fears his patents may have become public property. The Latour patents have also risen to add another element of confusion to the prevailing madhouse atmosphere.

Dr. Marius C. A. Latour, a French scientist, formerly in the employ of the General Electric Company, recently visited us with the glad tidings that there was scarcely a receiving set in use here which did not infringe some of his eighty basic patents. The Radio Corporation thought they had exclusive rights to these, but Professor Latour differed. Finally, after long negotiations, four non-exclusive licenses were issued to the American Telephone and Telegraph Company, the Postal Telegraph Company (purely for wire use), the Radio Corporation and the Freed-Eisemann Company. It now develops that the Hazeltine Corporation has bought control of the Latour corporation and threatens suits against all unlicensed users of the Latour devices.

Obviously those who have really put constructive effort into radio development will use the courts to maintain their rights. A lot of patent claims are bound to blow up in the next two years, and among the fragments will be many fly-by-nights and pirates who have worked the stock game to the limit. Unhappily, some legitimate enterprises will also suffer.

Kadel & Herbert

MILLIONS ARE INVESTED IN RADIO IN THE UNITED STATES

If you want to find out something of the value of the particular stock that you own, bring the stock certificates to a bank—and find out how much the bank will lend you on them. (The above picture was made in the plant of a concern that manufactures radio parts.)

But let us reason together. It isn't all hopeless. Radio will continue to develop despite the patent confusion and the industrial slump. Safety for the investor seems to lie inevitably with the big fellows, those which have the means to build up a broad patent structure, to defend it, and to prosecute extensive research.

Research, indeed, is the key to the future of radio. Systematic invention, as against empirical experiment, is almost bound to win. It is the laboratory against the work bench. Of course, outsiders will continue to invent, just as Professor Hazeltine did with his amazing mathematical formulas, but even there a scientist was at work. Amateur experiment is interesting, but it is also disorganized and sometimes incompetent. The cleverest of the amateurs are pretty sure to find their way into somebody's research laboratory.

It is through research that what looks to be the next great step in radio will have been taken.

Now they are talking super-regeneration which enables us to make one tube do the work of three. It is true that no commercial super-regenerative sets have yet been manufactured and sold. But the problem is an engineering one which is bound to be solved. The new thorium filament tubes which use less current because their electronic efficiency is heightened, new methods of more efficiently exhausting these tubes are likewise the result of research. Clearly, the organizations which cannot produce these improvements are going to be left either without anything to sell or will be forced to sell their obsolete produce at a price too low to guarantee profit.

Other factors, too, now dimly moving beind the continuous curtain of time, will influence radio as a business and as an investment. There is, for example, the gradual shaping of public opinion, reflected in Congress, toward the great public utility group of industries. Will it be actively inimical, inclined to regulation, or merely passive? The Radio Corporation, summoned into being, or at least godmothered by one branch of the government, is now being examined as a monopoly in restraint of trade by another branch of the government, the Federal Trade Commission. Is this a symptom? Or is the change in character within the Commission itself and the postponement of the present proceedings the vital symptom?

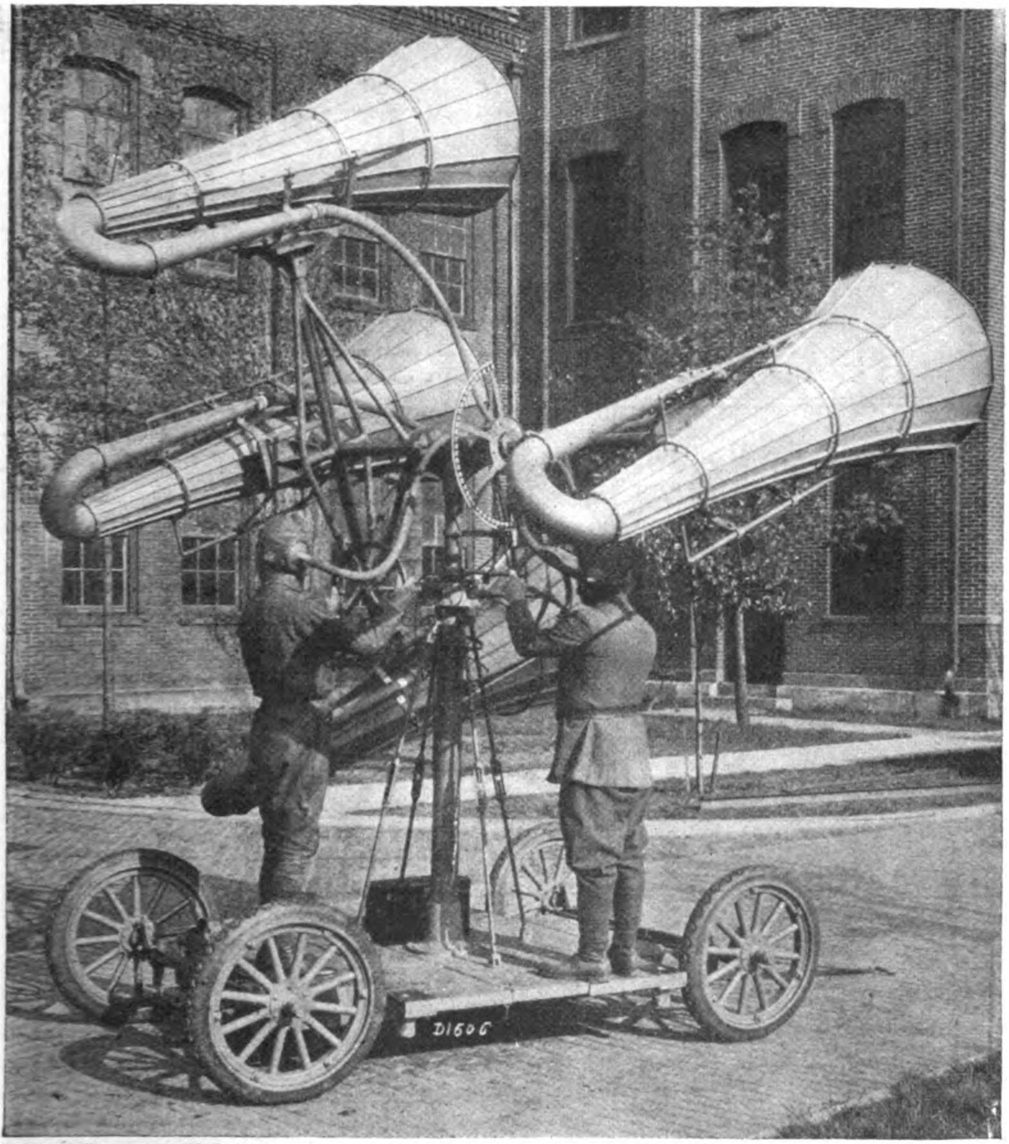
Then there is the matter of radio communication or radio telegraphy. There is no question of competition here. Radio Corporation controls it absolutely so far as private enterprise may, in face of the web of great government stations. A plotted chart showing a curve of radio set sales and another curve of returns from radio communication reveals some interesting trends. The curve for set sales is like the trajectory of a shell; it mounts spectacularly until recent months when the upward angle begins to diminish appreciably. The curve for radio communication, though flatter, doesn't diminish at all. It has remained steadily upward. Where will the two lines be ten years hence? Will they, like Einstein's parallel lines, meet each other at infinity, or will the set sales curve acquire a new energy? Few people realize that already twenty percent of the total telegraphic communication with Europe is handled by radio.

American Telephone and Telegraph is the most powerful agent of communication in the United States today. The agreements between A. T. & T. and Radio Corporation only run until 1929. If the telephone company, with its superb patent structure, ever decides to enter the field of radio, either in communication or set making, present estimates of the industry will have to be revised. Just now A. T. & T. understands telephonic radio transmission perhaps better than any other group and maintains what the public regards as some of the most efficient of the broadcasting stations. As the advance of radio is inextricably interwoven with the improvement and limitation of broadcasting this may or may not be significant.

But enough has been revealed here to show that the purchase of radio stock isn't quite so simple as it is made to seem. I am serenely aware that nothing I have said will check you if you have the bug. But if you have read this far you may at least be able to do a little blooping with the salesman before you sign on the dotted line.

How to Cut Down Interference in Reception

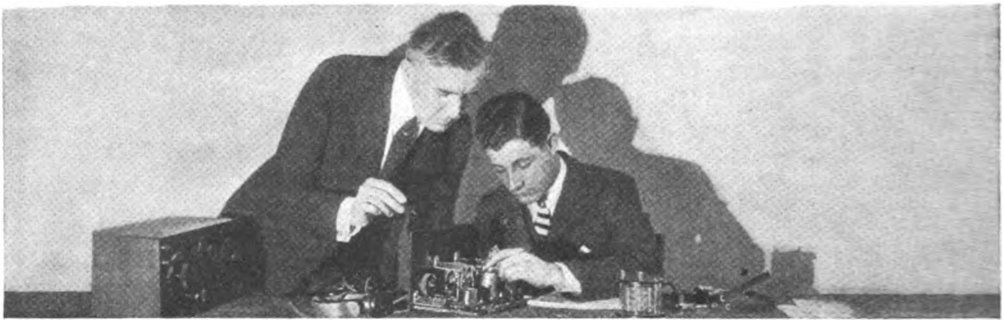
A helpful and essentially practical article on this timely topic will appear in POPULAR RADIO *next month—written by the well-known expert, John V. L. Hogan.*



Ordnance Department, U. S. Army

Listening Horns to Detect Aircraft

The United States Army has developed this ingenious listening device to detect the approach and position of hostile aircraft by means of the noise of the motors. The horns are designed on the so-called "exponential" equation, also used in designing some types of loudspeaker horns. One pair of horns follows the elevation of the sound; the other pair follows the sound around a horizontal circle. One operator controls each pair. The combined setting shows both the direction of the aircraft and its elevation angle. Corrections must be made, however, for the relatively slow speed of sound and for the "drift" caused by wind. The sensitivity of the horns could be increased, no doubt, by attaching microphones and audio-frequency amplifiers instead of the ear tubes.



IN THE EXPERIMENTER'S LABORATORY

Operating a Loop Receiver Near an Outdoor Antenna

MANY radio experimenters who have previously operated sets on the ordinary outdoor antenna have finally built a loop receiver and installed it on their radio table or bench and found that its selectivity is not what they expected. This, in many cases, is due to the fact that when the outdoor antenna lead-in wire runs near the loop antenna it gives too great a pick-up for the ultra-sensitive loop receiver, causing lack of selectivity. A loop receiver should be operated at least fifteen feet distant from the lead-in wire to be of the required selectiveness.

If you want to test out the loop receiver to find its true selectivity, it is always best to curl up the lead-in wire and leave the outdoor antenna ungrounded. In this way its effect of energizing the loop will be negligible and the true directional characteristics of the loop antenna may be employed.

Tubes for Resistance-coupled Amplification

THERE are some new tubes now being placed on the market for use with resistance-coupled amplifiers. These tubes have a higher "mu" and thus will enable the user to obtain greater amplification when used with this type of amplifier. They run in amplification with a ratio of about 20 to 8, which is about two and one-half times that obtained with the standard tubes.

Soldering Connections

WHEN soldering the wires in a receiving set, the experimenter should always be careful to use soldering flux or paste sparingly, wiping off each joint after the connection has been made, to be sure that no superfluous paste or liquid is left on the joint or on the insulation surrounding the joint. This will prevent corrosion of the joint itself and will also prevent leakage across any insulating materials, which might decrease the efficiency of the receiver or transmitter that is being wired up.

When soldering leads to taps on an inductance be sure that the silk or cotton covering on the wire is first scraped back out of the way before the soldering flux or paste is applied. This will prevent the hot flux or paste from running up along the insulation and causing a short-circuited or partly short-circuited turn in the coil.

"Straightline Frequency" Condensers

THE latest development in condensers that seems to overshadow, at present, the "low-loss theme" is "straightline frequency."

Condensers, to date, are constructed so that as the dial setting is varied the capacity will vary proportionately and the area of the meshed plates will vary uniformly. But, it has been determined, that, as the wavelengths of the broadcasting stations are allocated according to frequencies, the old type of condenser normally known as the "straightline-capacity type, crowds the low-wave stations too closely.

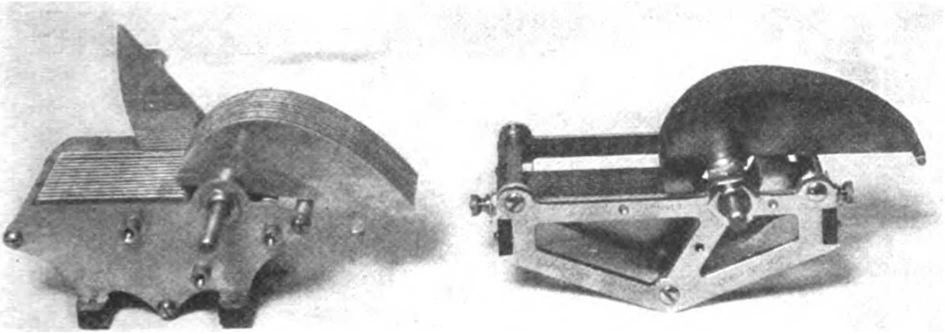
Frequency is figured from the formula

$$f = \frac{1{,}000{,}000}{2\pi \sqrt{LC}} = \frac{159{,}154}{\sqrt{LC}} \quad \ldots\ldots \; 1$$

where f = frequency in cycles per second, C = capacity in microfarads, and L = inductance in microhenries. In this case we may regard the inductance, L, as unity and therefore not consider it in the formula,

$$\text{so that } f = \frac{159{,}154}{\sqrt{C}} \quad \ldots\ldots\ldots\ldots \; 2$$

Therefore, it will be seen that the frequency will vary inversely as the square of the capacity. In a condenser this means that in order to space the frequencies of the stations evenly over the dial the meshed condenser plates must vary as the square of their areas. Thus, if at a frequency of 1,250,000 cycles (240 meters), the included area of all the



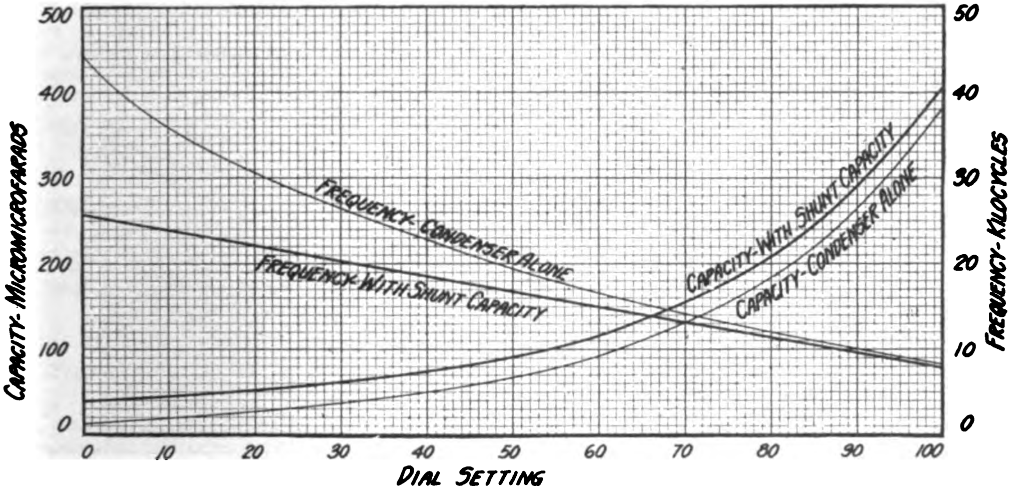
THE ROTOR PLATE DESIGN FOR STRAIGHTLINE-FREQUENCY CONDENSERS

FIGURE 1: *Here are shown two new types of straightline-frequency variable condensers. The condenser on the left contains also a compensating plate that forms a shunt capacity across the condenser which can be varied. This enables the condenser to be set so that it will give a straight-line-frequency curve with almost any type of tuning coil.*

condenser plates is figured to be 6 square inches, then, at half that frequency, 625,000 cycles (480 meters), the included area of the meshed plates would have to be 36 square inches and so on.

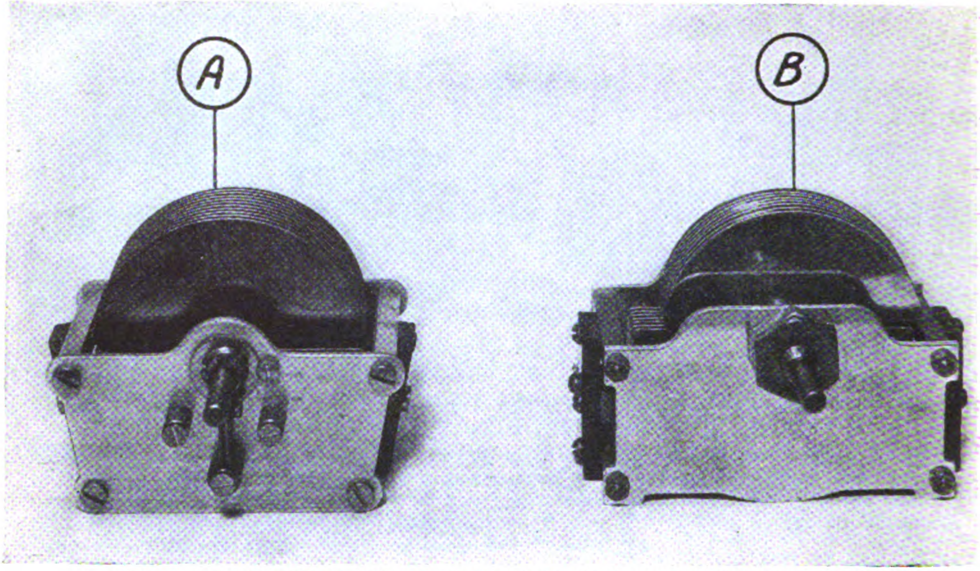
Neglecting all other capacities outside the condenser such as distributed capacity of coils the shape of such a plate would be as shown in Figure 1. The curves for this condenser are shown in Figure 2.

Such a condenser would be just the thing for spacing the frequencies evenly over the dial, but as soon as the condenser is coupled in a radio set to some part of the circuit, then the distributed capacity of the coils connected with it (and even the connections to a slight degree) will affect the capacity of the condenser and likewise the straight-line-frequency characteristic. Laboratory tests and experiments have shown that ordinary coils coupled to the



EVALUATED CONDENSER CHARACTERISTICS IN CHART FORM

FIGURE 2: *These curves show the characteristics of the left-hand condenser shown in Figure 1. The lower capacity curve marked "condenser alone," shows the continuing various values of capacity with dial setting. This gives the frequency curve shown under the heading "frequency-condenser alone." It will be noted that this curve has a slight curve characteristic. To make it a straightline, a shunt capacity must be added as shown in the top capacity curve. This gives the straight-line-frequency curve which is marked on the chart "frequency- with shunt capacity." In this way the condenser with the compensating plate can be adjusted so that it will give a straight-line-frequency characteristic with any type of coil.*



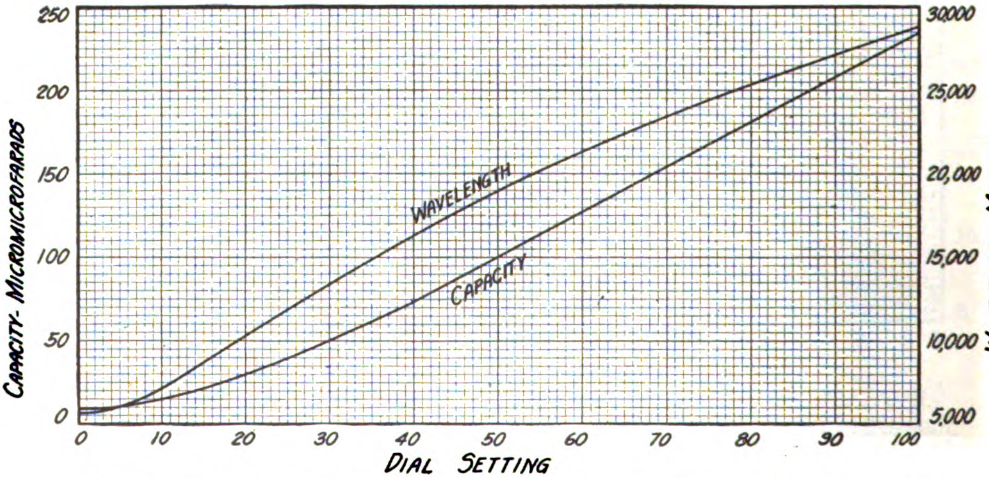
THE TWO PREVIOUS TYPES OF VARIABLE CONDENSERS

FIGURE 3: *The condenser "A" is a straight-line-capacity condenser in which the capacity varies directly as the dial setting. The condenser "B" is a straight-line-wavelength condenser which is supposed to prevent crowding at the lower wavelengths.*

condenser vary up to approximately .000025 microfarads in distributed capacity. Coils with a small number of turns may have .000005 microfarads distributed capacity. One manufacturer of the new type of condenser, in order to offset this effect, adds an extra end plate, which has the appearance of the old time vernier. He has so figured his condenser that when the end plate is fully meshed the resultant readings are absolutely straightline in frequency. This plate can be so adjusted as to compensate for the distributed capacity of the coil in the circuit.

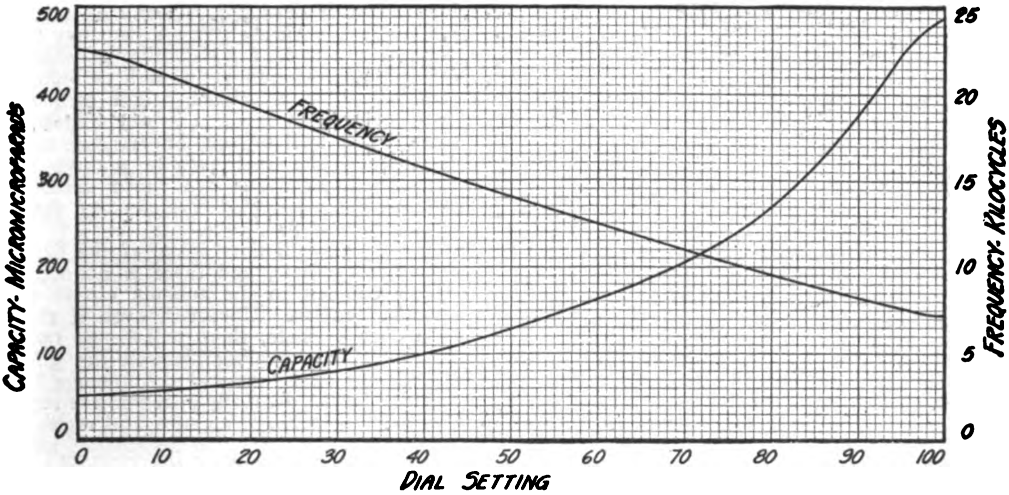
To design a straightline frequency condenser properly a capacity curve for a condenser of the desired capacity should be drawn first, ignoring coil capacities.

Then a second curve should be drawn, deducting a certain amount of capacity corresponding to the distributed capacity of the



WAVELENGTH AND CAPACITY CURVES FOR THE STRAIGHT-LINE-WAVELENGTH CONDENSER

FIGURE 4: *A study of the above capacity curves and its corresponding wavelength shows that this condenser although it does distribute the lower wavelength slightly over the dial, is not as effective as the straight-line-frequency condensers for this purpose.*



IDEAL CHARACTERISTICS FOR THE STRAIGHT-LINE-FREQUENCY VARIABLE CONDENSER

FIGURE 5: *This curve gives the data for the proper capacity settings against dial settings in order to have an ideal straight-line-frequency condenser. The capacity as denoted in the lower curve includes both the capacity of the condenser and the distributed capacity of the coil. To find the correct capacity to be incorporated in the condenser, the distributed capacity of the coil must subtract all along the line.*

coil to be used, say .000025 microfarads, from the first curve.

This will then give the actual capacities of the condenser at various dial settings.

The truth of the whole matter is this; there is really no such thing as a straight line-frequency condenser, except when considered in connection with a particular type and size of coil.

—MORRIS M. SILVER

Single-circuit Receivers

IT is recommended that single-circuit receivers (that is, those circuits in which the input circuit to the tube is also a conductive part of the antenna circuit), should not be used in crowded areas where receivers are located closer than half a mile apart. These simple receivers, if they are of the regenerative type, will cause great disturbance in neighboring sets because they radiate a wave in the same manner that the broadcasting stations do, except that the waves are of smaller intensity.

These simple circuits have been found to be useful in portable sets used in the country or in any place where neighboring receivers are not closer than half a mile or so, but in the city their use should be prohibited by mutual consent of all radio users.

Radiation or So Called "Re-radiation"

THERE seems to be considerable misunderstanding regarding the question of radiation. Many fans seem to be under the impression that a receiver which contains one or more stages of radio frequency amplification cannot radiate. On the other hand, there is another faction which labors under the belief that any receiver which squeals also radiates.

Both of these impressions are wrong.

Many of the receivers which include one or more stages of radio frequency amplification radiate as freely as the "single circuit" type. On the other hand some regenerative receivers which whistle freely when tuned while in an oscillating condition will not radiate.

It is true that any receiver which is capable of oscillation is capable of radiating. However, in some types of receivers this radiation is possible only from the coils of the receiver—not from the antenna—and therefore is effective only a few feet from the receiver.

In the case of the Four-circuit receiver, for instance, a test was recently made to determine its radiation qualities. In the test two other sensitive receivers were used, and two antennas. The Four-circuit receiver was connected up to one antenna and put into regular operation. In the same room a tuned radio frequency receiver loop was set up and also put into operation. When the Four-circuit receiver was made to oscillate, the oscillations were picked up faintly with the other receiver but—and this is important—the oscillation was picked up equally well whether the antenna was connected to the Four-circuit receiver or not.

This proved that the slight radiation no-

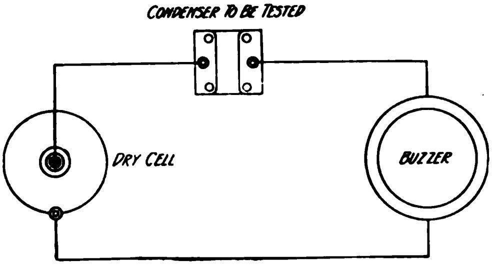


FIGURE 6: *This simple circuit shows the manner of connecting a condenser with dry cell and buzzer for testing of short-circuits.*

ticed was coming from the receiver direct, rather than through the antenna.

Next, the loop receiver was moved into the next room and another test made. This time no radiation could be picked up from the Four-circuit, with or without an antenna.

Finally, a third receiver was connected to an antenna which ran almost parallel with the one connected to the Four-circuit, and about 15 feet distant from the latter. When both receivers were put in operation, absolutely no interference was noticed in the other receiver, although the Four-circuit set was oscillating continuously.

This gave conclusive evidence that the Four-circuit receiver does not radiate, in spite of the fact that it can be made to oscillate, especially on the lower wavelengths.

The fact that a receiver is used with a loop rather than with an outdoor antenna does not prevent it from radiating. Many superheterodynes cause considerable interference to neighboring receivers, even when operated on a loop. But it does not follow that all superheterodynes radiate. Where the first tube is used as a stage of non-oscillating radio frequency amplification there is little danger of radiation. Or a balancing coil arrangement may be used, as in the Pressley Superheterodyne, which will prevent interference to other receivers. The real trouble makers among the superheterodynes are those which have the oscillator coupled directly to the grid circuit of the first tube.

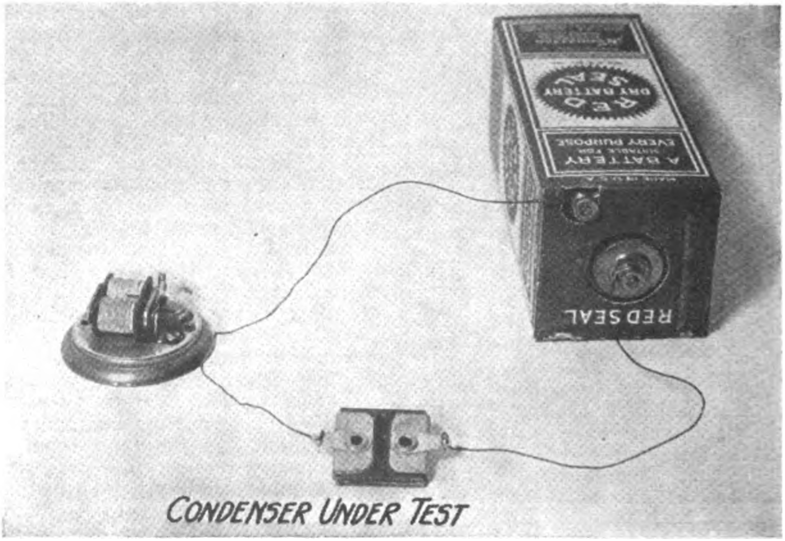
A receiver will not radiate if the first tube does not oscillate, and there is no oscillating circuit coupled to the antenna circuit or the antenna coupler. Moreover, even if the first tube does oscillate, there will be no radiation providing the coupling between the grid circuit of the first tube and the antenna is sufficiently loose. In many regenerative receivers the coupling between antenna and regenerative detector cannot be made sufficiently loose to prevent radiation and at the same time provide satisfactory reception. The Four-circuit receiver works best with extremely loose coupling, the coupling consisting of the single turn which is wound around the stabilizer coil. It is this extremely loose coupling that prevents it from radiating.

—S. GORDON TAYLOR

Shooting Trouble in Condensers

WHEN trouble is encountered in a radio receiver it is frequently desired to test the fixed and variable condensers to make sure they are O. K.

There are two main possibilities of trouble in condensers, *i.e.:* short-circuit between plates and poor internal connections.



HOW THE BUZZER TEST LOOKS

FIGURE 7: *This shows the set-up diagramed in Figure 6 for testing fixed condensers to find out if they are short-circuited or not. If the buzzer operates, the insulation in the condenser is broken down and it is useless.*

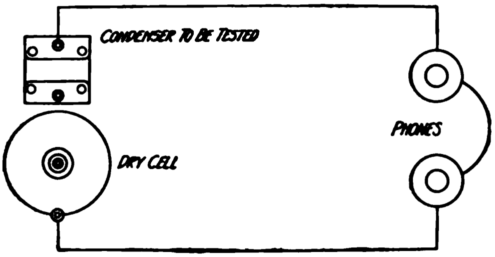


FIGURE 8: *The wiring diagram for testing condensers for leakage.*

The test for a complete short circuit in either fixed or variable condensers is simple. It is necessary only to connect the condenser in series with a battery and buzzer as shown in Figures 6 and 7. If the buzzer operates it is an indication of a complete short. If it does not operate, however, there is no complete short. This test does not show a partial short-circuit. In making such a test the condenser must, of course, be disconnected from the receiver.

There is a single test for both of these defects in the ordinary small condensers used in radio receivers. This test is simple but, nevertheless, some care will have to be exercised to make it effective. When a direct current, as from a 1½ volt battery, is allowed to flow through a circuit in which a series condenser is connected, the current will flow for only a fraction of a second, or until the condenser becomes charged. If phones are in the circuit during that time, the momentary current flow will result in a single audible click in the phones. Even if the circuit is broken and immediately connected again, there will be no further current flow in the circuit. If current does flow it indicates a defective condenser. Such a test circuit is shown in Figure 8.

If a path is provided from one side of the condenser to the other, without the battery in the circuit, there will be another flow of current while the condenser discharges the energy which it has stored up. If the finger is placed across the two ends of the condenser, for instance, this energy will flow through the finger. Or if the phones are connected directly across the condenser the energy will flow through the phones, resulting in another audible click. This is a sure sign of a good condenser.

Perhaps the surest way to make this test, to avoid any undesirable leakage path, is shown in Figure 9. Connect one phone tip to the negative side of a dry-cell and hold the other phone tip against one end of the condenser with the fingers (being sure that the fingers do not touch the other end of the condenser). Now tap this other end of the condenser against the positive pole of the battery. At the first tap there should be a comparatively faint click. At the second tap there should be no click because the condenser was charged at the first contact. Now touch this end of the condenser to the negative pole of the battery. In effect this connects the phones across the condenser, allowing the charge to leak off through the phones, making another click.

To sum up: a condenser is short circuited if a click is heard every time the battery circuit is connected, provided the circuit is disconnected and reconnected rapidly. The current is then not stored up in the condenser but flows right through. If no click is heard at all, there is a poor connection inside the condenser which does not permit the current to flow into the condenser, and therefore the condenser can neither charge nor discharge. Due care must be exercised in all cases to prevent any leakage path across the condenser while it is charged, such, for instance, as holding the finger across both ends of the condenser during the test. If this is done the condenser will discharge as quickly as it is charged and the effectiveness of the test will be spoiled.

—S. GORDON TAYLOR

An Oscillating Wavemeter

THE PARTS USED IN THE OSCILLATING WAVEMETER—

A—4½ volt "C" battery, Eveready type No. 771;

B—Small size 22½ volt "B" battery, Eveready type No. 763;

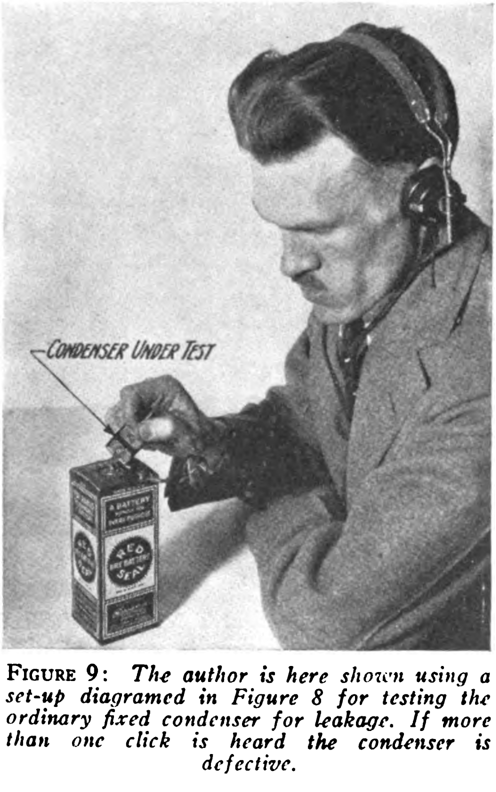
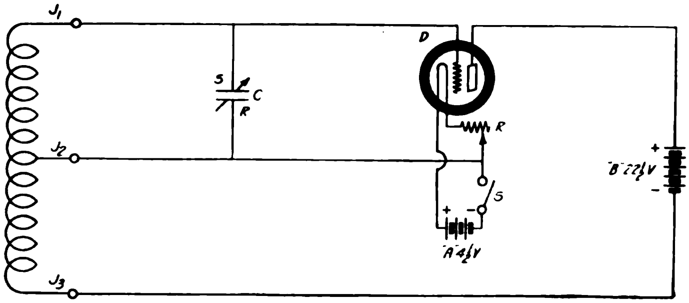


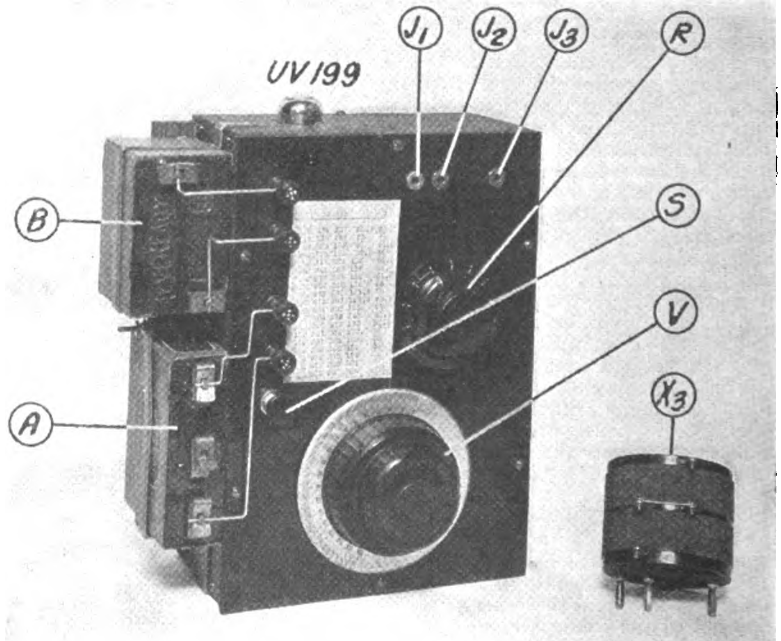
FIGURE 9: *The author is here shown using a set-up diagramed in Figure 8 for testing the ordinary fixed condenser for leakage. If more than one click is heard the condenser is defective.*



THE WIRING DIAGRAM FOR THE NEW OSCILLATING WAVEMETER

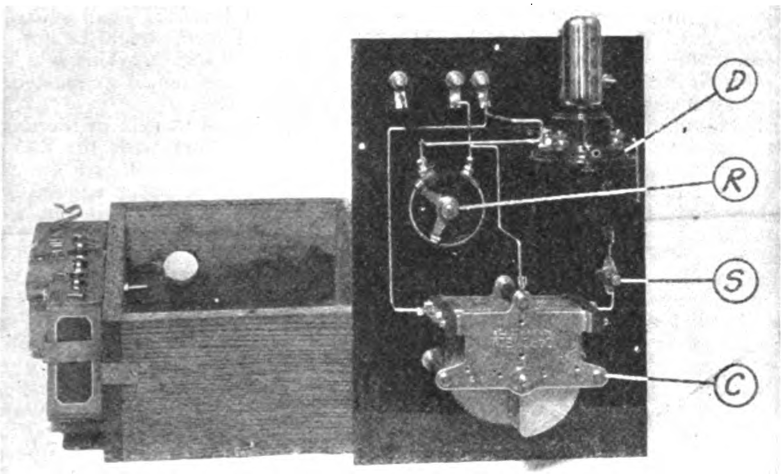
FIGURE 10: *This diagram gives the hook-up for the wavemeter. All the symbols for the coils, condensers and other instruments bear designating letters which are used in the list of parts and throughout the text and illustrations.*

C—Cardwell .0005 mfd. variable condenser, 21 plate;
D—Na-ald No. 499 socket for UV-199 tube, equipped with Na-ald panel mounting No. 460;
J1, J2 and J3—General Radio coil mounting jacks, No. 274J;
P—12 General Radio coil contact plugs, type 274P (3 used with each coil).
R—General Instrument 30 ohm rheostat;
S—Benjamin Battery switch;
V—Accuratune vernier dial, 4 inch diameter;
X1—General radio inductance coil No. 277A, without plugs;
X2—General radio inductance coil No. 277B, without plugs;
X3—General radio inductance coil No. 277C, without plugs;
X4—General radio inductance coil No. 277E, without plugs;
1 composition panel, 7 inches by 10 inches;
4 Eby binding posts;



THE FRONT VIEW OF THE OSCILLATING WAVEMETER AND ONE OF THE COILS

FIGURE 11: *This picture gives an idea of how the wavemeter looks when viewed from the front. As all the parts and accessories are marked with designating letters, the prospective operator will have no trouble in locating the various controls as they are explained in the text. In operation any one of the four coils may be used by plugging into the three jacks, J1, J2 and J3.*



THE INSIDE VIEW OF THE OSCILLATING WAVEMETER

FIGURE 12: *This gives the general arrangement of the instrument fastened to the panel and shows how the two batteries are attached to the cabinet. It also shows the hole which is made in the top of the cabinet for inserting the vacuum tube.*

Lumber, screws, strap brass—18 inches by ½ inch by 3/32 inch.

ONE of the most important pieces of equipment that a radio experimenter can have is an oscillator wavemeter such as the one to be described below. This instrument serves not only as an accurate and precise reading wavemeter, but also as a standard for measuring capacities, inductance and other details.

In making your own coils, this instrument enables you to tell the exact waveband the coil will cover; it also enables you to measure the capacity of small fixed condensers, the maximum capacity of variable condensers and your antenna capacity.

With it it is possible to tell in an instant the wavelength of a broadcasting station to which your receiver is tuned.

This article is confined to the construction and operating directions for the oscillator used as a wavemeter; in a later issue more data will be given on the use of this instrument for measuring condenser capacities and coils.

The circuit used in the oscillator is a modification of the Hartley Circuit; it is shown in Figure 10.

The coils are fixed and are connected into the circuit by a plug arrangement which provides a simple and satisfactory way of changing coils for different wavebands.

The construction of the oscillator is clear from the illustrations. It will be noted that the coil, tube and "B" battery are placed well away from the dial for the purpose of eliminating body capacity. It is for the same reason that the variable condenser is shunted across only one half of the coil rather than across the entire coil.

Four coils are used, and they cover the wavebands as follows:

X1—33 to 100 meters
X2—65 to 206 meters
X3—127 to 398 meters
X4—194 to 602 meters

As will be noticed this set of four coils covers all of the broadcast band and also the amateur 150-200 and 75-85 and 37-42 meter bands.

It is best to use only the upper part of the oscillator dial—from 30 to 180 if accurate readings are desired.

It is extremely important that no changes be made in the oscillator after it is once calibrated, otherwise recalibration will be necessary. Even the position of the batteries in relation to the oscillator must remain fixed. It is for that reason that the batteries are attached directly to the case of the oscillator, as shown in Figure 2. Variations in rheostat setting or battery voltage will, however, have little effect on the dial setting, and as a rule the use of a different tube of the same type as the one used when the oscillator is calibrated will not materially affect the calibration. It is well to always use the same tube, thus eliminating any possible chance of variation from the calibration.

There are several ways of calibrating the oscillator. The first and best way is to calibrate it by means of a standard oscillator—if the use of one can be obtained. The next best plan is to listen in on the standard frequency signals sent out from the Bureau of Standards in Washington. These are sent out on the 5th and 20th of every month, beginning at 10 P.M. Each evening a band of frequencies is covered. One evening, for instance, the band from 545 meters down to

200 meters is covered; the next transmission night the band from 200 to 100 meters is covered. The schedule of transmissions may be obtained from the *Radio Bulletin* issued monthly by the Government Printing Office; it may be purchased for five cents a copy.

The third and most usual method of calibrating the oscillator is to use the wavelengths of broadcasting stations.

To do this a number of broadcasting stations, ranging from the lower to the upper wavelengths, are tuned in on any type of ordinary receiver. When a station has been tuned in the oscillator is placed about three feet from the receiver, the oscillator tube is lighted and the dial rotated until the familiar heterodyne whistle is heard as the oscillator is tuned to resonance with the receiver (and therefore also with the transmitter of the broadcasting station). As the wavelength of the broadcasting station is approached on the oscillator dial the whistle will first be high pitched. As the dial is turned further the whistle will become lower until it is no longer audible. At this point the oscillator is in exact resonance with the broadcasting station. If the dial is turned too far the note once more rises, an indication that the dial has been turned too far.

When the oscillator has been tuned to resonance in this manner make a note of the reading of its dial, together with the wavelength of the broadcasting station. Now repeat this operation on different stations, obtaining a goodly number of calibration points.

The method of calibrating the smaller coils by the harmonics of the higher wavelengths will be explained in a later issue.

To make up the calibration "curve" or chart, a piece of cross-section paper will be helpful, preferably the style with 20 lines to the inch, both vertical and horizontal, dividing each square inch into 400 small squares. The size of the ruled form should be not less than 6½ inches by 9½ inches. This is a standard size which can be obtained at most draughtsmen's supply stores.

The left hand margin of the sheet is marked off to correspond with the dial, the bottom line being marked 30 and the top line 180, if the above size paper is used. Every tenth line is marked, the tenth from the bottom marked 40, the twentieth 50, and so on. This applies in cases where a 180 degree dial is used on the oscillator. If a 100 degree dial is used the bottom line may be marked 0, the tenth line 10, and so on.

The bottom margin is marked with wavelengths. Where the coil being calibrated is one which covers the broadcasting waveband the left-hand line is marked 200 and the right-hand line 600. Then every vertical line represents 2 meters and every tenth line is marked accordingly.

To spot the calibration points, find the intersection of the dial setting and the wavelength. For instance, the eightieth line from the left represents 360 meters. If a reading has been taken on a 360 meter station the eightieth line is followed up to where it intersects the horizontal line corresponding with the oscillator dial setting for that station. At this intersection a dot is made, and all of the other calibration points are marked in the same way. After they are all marked in, connect them together with a line and the "curve" will be completed. Such a set of curves is shown in Figure 5.

The method of using the oscillator and the "curve" is simple. Suppose a broadcasting station is tuned in on a receiver (not necessarily the same receiver used in obtaining

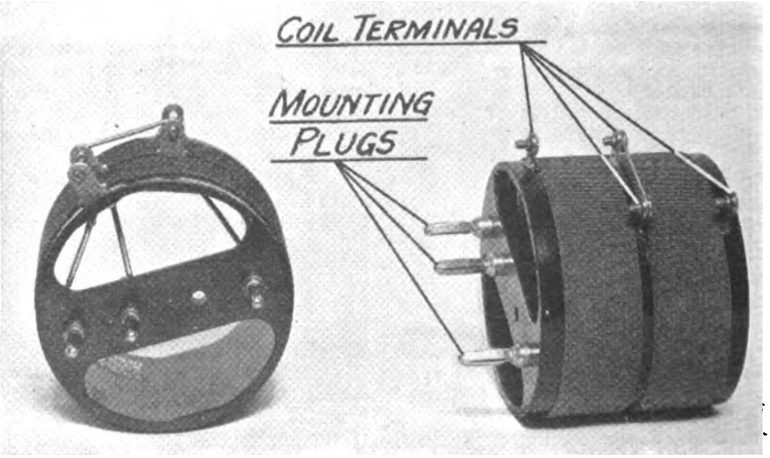
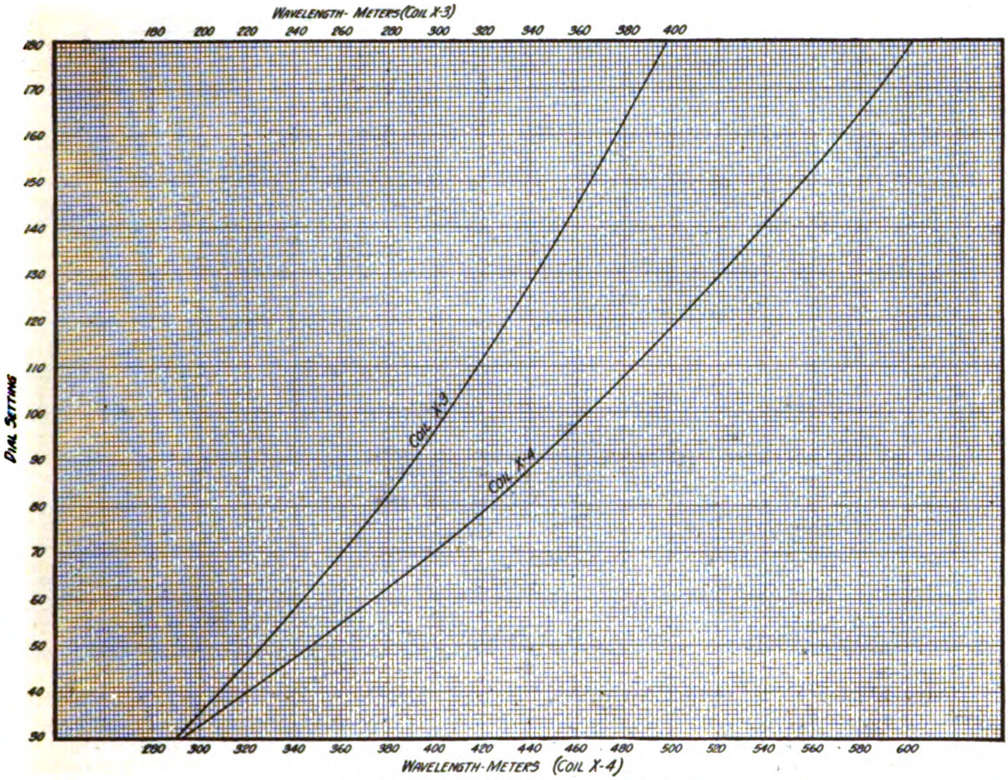


FIGURE 13: *Two of the coils and the method of mounting plugs on the cross strip provided on the coil form. Four holes will be found in the cross strip but only three of them are used. In the left-hand picture, the first plug on the left is connected to the front end of the coil; the second one is connected to the center tap and the third right-hand plug is connected to the rear end of the coil. The two inner coil terminals are connected together with a piece of wire as shown.*



A SAMPLE TUNING CHART

Figure 14: *This diagram shows how two tuning curves were made for coils, X4 and X3. This is the kind of chart which the author tells how to make in the text of his article. With one of these charts and the oscillator described, the experimenter is able to tell the wavelength of any incoming signal that he picks up with his receiver.*

the calibration points) and it is desired to know what station it is, or what the wavelength is. The oscillator is turned on and its dial rotated very slowly until the whistle is heard. The dial setting of the oscillator is noted. Referring to the "curve" the horizontal line representing this dial setting is followed across until it intersects the "curve." The vertical line nearest this point of intersection represents the desired wavelength.

The cabinet shown in the illustration can be easily made. Its inside dimensions are 6 inches by 9 inches by 3½ inches deep. A small shelf is mounted on one side for the batteries and a piece of strap brass is bent to fit the batteries and is screwed on to the side of the cabinet. A threaded rod is provided at the center of the brass bracket to tighten it against the batteries, holding them securely in place.

—S. Gordon Taylor

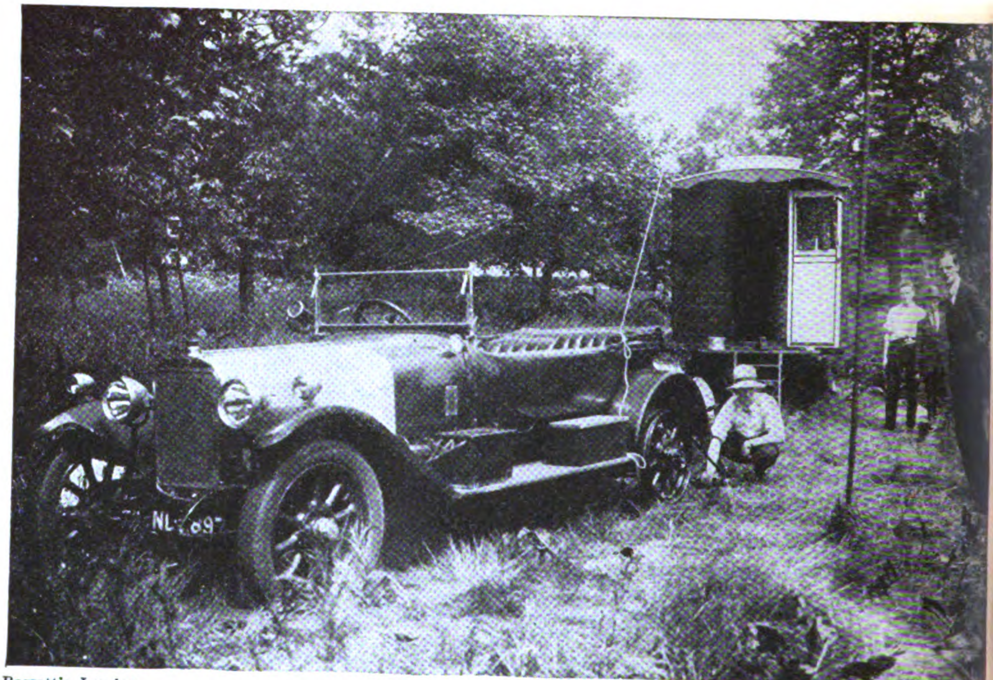
A Power Tube in the Last Stage of Audio

It is often advisable to use a power tube, such as the VT-2 or the 216-a tube, in the last stage of audio-frequency amplification. This will usually help considerably in getting better quality from the receiver, especially if the receiver uses radio-frequency amplification ahead of the detector.

If a power tube is used, be sure that the last rheostat has sufficient current carrying capacity for the tube you use. If it has not, it should be changed and the proper rheostat installed. In the case of Amperite filament adjusters, the ordinary type No. 1-a (which is used with the 201-a type tubes) should be taken out and an Amperite No. 1 substituted. This latter type will accommodate the so-called power tube.

"How to Compare Losses in Condensers"

Useful information—based on laboratory experiments—that every radio amateur should have, will appear in Popular Radio *for next month.*



Barratt's, London

AN ENGLISH "RADIO CARAVAN" THAT COMMUNICATED WITH AMERICA

An enterprising and inventive English radio experimenter recently succeeded in communicating with amateurs across the Atlantic by using a transmitting equipment which obtained its power from the rear wheel of his motor car. The rear end of the car was belted to a high voltage generator which supplied the current to the plates of the vacuum tubes employed.

The BROADCAST LISTENER

Comments on radio programs, methods and technique —from the point of view of the average fan

By RAYMOND FRANCIS YATES

Why German Programs in America?

THE artful publicity department of the Radio Corporation of America probably thought it was dropping a great big bombshell when it announced that the German broadcasting station was going to export its programs to America and that they were going to be rebroadcast here. The announcement was received coolly in our department, however, for, while we anticipate the day when the entertainment of the nations of the world will mix and blend in the great amphitheater of the ether, we are, for the time being at least, perfectly satisfied with the American-made product. This decision is not the result of a patriotism so intolerant that it cannot condone the thought of music from the Deutschland. As a matter of fact, there is a place in this big heart of ours for the worst-sounding, beer-drinking German band that ever inflated its red cheeks. Our argument is, "Ladies and Gentlemen of the radiophone audience," that the exchange of foreign programs can be nothing but an amusing experiment made to order for the publicity departments of the various corporations concerned. As a diversion for a night or two, it receives our very official O.K., but technical radio is not ready to extend this into a lasting performance of a really meritorious nature.

* * *

Something Novel on a Program

WHEN our field department wired us from Cincinnati that the Crosley station had installed a new feature, we were all aflutter. Any studio manager who is caught doing a little thinking in an effort to inject fresh blood into the fast hardening veins of the art, will find the full power of this department squarely behind him. We don't care if it is the simple trick of permitting a pig to squeal into the microphone; as long as a pig has never squealed into a microphone before (and we really don't know why pigs have never been permitted to squeal into microphones), we shall be back of the pig-squealing movement heart and soul. The trouble with radio (or one of the troubles at least) is that studio managers are not experimentally inclined. When KDKA broadcast its first program, it set down a pattern that has been followed ever since.

WLW is using a novel method to present the daily news, and while it may not be very exciting as excitement is measured in these days of petting parties and uncovered feminine knees, it is pretty good for so young and yet so mossy a thing as radio broadcasting. WLW mixes news items with music, reading a piece of news and then playing an appropriate (or as near appropriate as possible) selection. Although the brief wire of our Cincinnati attache does not so state, we presume when a news item concerning the K.O. of a pugilist is read, that the orchestra lapses into the plaintive strains of "I Dreamt I Dwelt in Marble Halls." This may be a little far-fetched, but it is the best example we can think of at this time.

* * *

The "Invisible Guest"

Long years ago, when we were annoying the readers of the New York *Herald-Tribune* with clumsy paragraphs very similar to the present run, Mrs. Marie Hemstreet contributed a little poem that we liked a great deal because it pleasantly expressed sentiments of our own concerning the constant reference made by announcers to the "invisible guests." One is very uncomfortably reminded of a spiritual seance because that is really the only place you would expect friends in the proto-plasmic realm. Mrs. Hemstreet objects with poetry:

There is one thing I hate to be called,
Against it I boldly protest;
It gives me a shiver,
A chill on the liver,
To be hailed as "invisible guest."

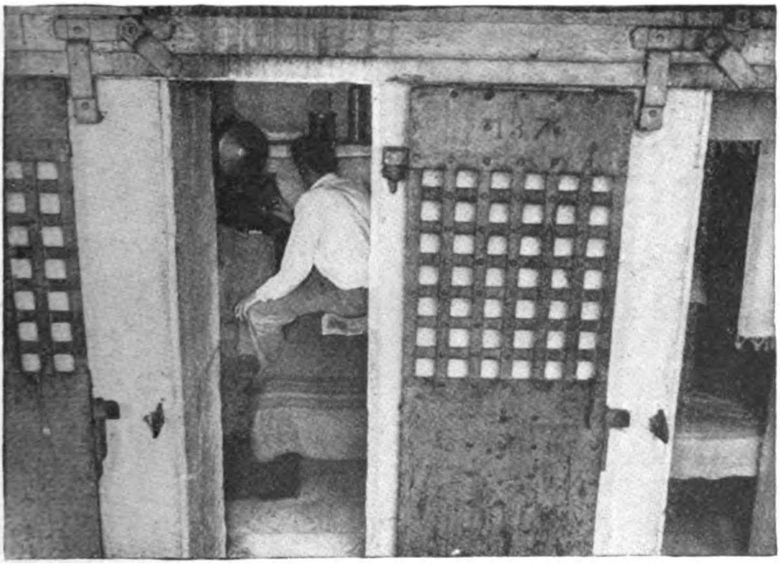
It's hard to imagine the ether,
As crawling with bodiless hosts,
But it gives me the creeps,
When a voice from the deeps,
Seeks to claim me as one of the ghosts.

When you call me "dear friend" or
"dear fan,"
I'll tune in with fervor and zest,
But somehow I quiver,
And cannot but shiver,
When hailed as "invisible guest."

* * *

This Month's Cake Is Awarded

Continuing our practice of including one little puff of simon-pure praise each month, we wish to lay a wreath at the door of the Eveready Entertainers. The nice thing about



Kadel & Herbert

HOW A STATE'S PRISON INMATE EVADES THE LONELINESS OF CELL LIFE

Radio is a magic fluid that seeps into every crevice of human life—even through prison walls. Here is a Sing Sing prisoner manipulating a curious radio set built by himself.

the Eveready Entertainers is the delightfully reckless way in which they abuse the most sacred traditons of the art, for the habitual listener of WEAR, WSAI, WEEI, WJAR, WOC and WEAF must feel with us that Eveready entertainment is unusually good to the point of being actually satisfying. It seems that a perfectly appalling amount of thought and painstaking effort has been put into the construction of these weekly events. They should be a great inspiration to the hundreds of studio directors with heads filled with ground-up corn cobs.

* * *

A Real Nut Comedian on the Air

While we are at it, we may as well add another dash of parsley to this unpalatable dish of arid hokum. We wish, in this case, to extol Harry Richman, who is perhaps the most outlandishly foolish man on the air. To say that he is the most outlandishly foolish man on the air is saying a pretty large mouthful, too, when we stop to think things over. Yet with all of his downright foolishment, he is a powerfully funny man, and the weak old thing that runs this department has been a subscriber of his since the second night he came to the air through WHN—yes, it's a little over a year ago now.

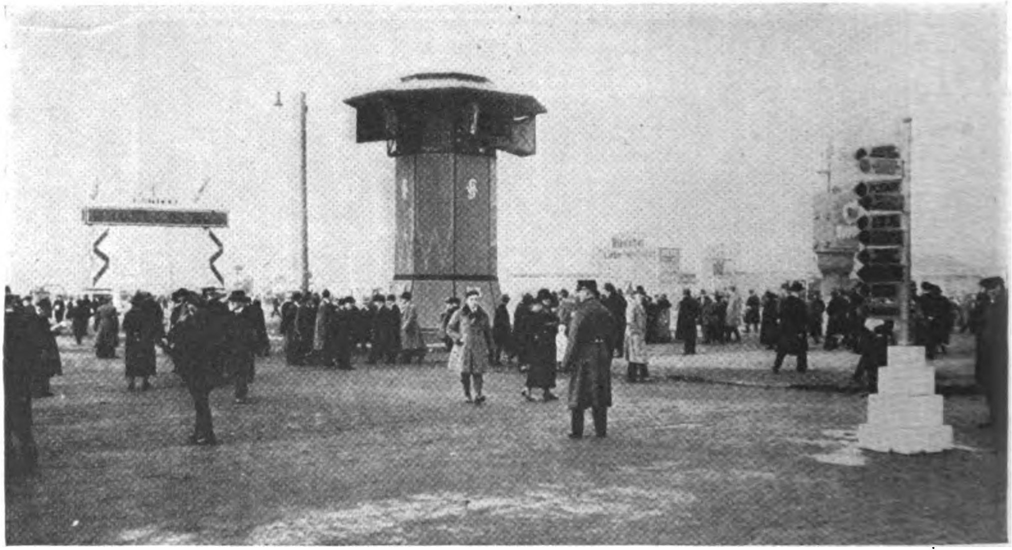
It takes a good man to be so foolish that he is funny. Most of the super-nutty comedians are just foolish without being funny, which is a most pathetic status. While Harry Richman unloads many scuttles of utter craziness, one finds in much of it kernels of real subtle humor. To say that one was dining with a big rubber man from the Turkish Baths or that one went to the theater with a large collar man from Great Neck or that the evening was spent with a big locksmith man from Key West is, to our way of thinking, a pretty steamy line of talk. All of which goes to show how easily a man like Richman can take on customers like us.

* * *

Talky Announcers

Some day when we are under a little less social pressure, we are going to look up the WEAF, WJZ, WJY, KDKA, WMAQ and WFI programs of a year back and publish them with the programs of the present time. This would be, perhaps, the most effective way of saying that radio is hog-tied to the hitching posts of broadcast tradition and that the majority of our impresarios and *entrepreneurs* are at the very end of their wits. If you changed the date on any one of these program cards, it would be just about all you would have to do to bring them right up to the minute as the classiest and newest means of cooking up a batch of entertainment for the yokels "out there."

With the precious few announcers that we have who know how to carry on an intelligent, connected conversation free from "ands" and "buts," we often wonder if the bare announcement of the station, the number and the artist would not be the wisest course to



F. M. Delano, Paris

THE ALUMINUM LOUDSPEAKER SPEAKS

This gigantic loudspeaker, which was set up on the grounds of the Leipsig Fair in Germany, consumed approximately one horse-power of electric current, which was sufficient to send the sound waves scurrying over the entire exhibition. This loudspeaker operates with a thin aluminum ribbon pulled taut between the poles of a powerful electromagnet.

follow. Surely that would be better than listening to a long line of grammatical goulash, which, after all, is simply designed to say, "This is station BXW, Buffalo, N. Y. John Jones will play 'Home Sweet Home' on the harmonica."

It is certainly amusing to hear some of the patter that is offered as intelligent comment by talky announcers. There is one chap in New York (we'd hate to mention his name because he took us out to lunch one day, poor devil; we're pretty decent after all, aren't we?) who offers the rarest bit of irrelevant matter that you would care to listen to every time he approaches the microphone. He is perhaps the most capable oratorical kaleidoscope that has ever faced a microphone. The photographic rhapsody of a Pathé news reel is an example of unblemished harmony when compared to the thoughts commented upon by this young man in the course of a single minute. Metaphysics, baseball, music, pancakes, flowers, race horses, subways and hardware are some of the subjects that you might find in any one of the little rhetorical grab-bags that he injects into the program at the end of each studio feature.

We don't mind being announced at in the conventional manner by men like Milton Cross (WJZ) or Thomas Cowan (WNYC), but we are awfully sensitive to the intellectual white wash peddled by the average young man who, by some dirty trick of fate, has found himself in a radio studio.

And that's that!

Underwood & Underwood

A BROADCAST ARTIST WINS A FORTUNE

So gentle and soothing was the jazz symphony music played by Paul Ash that a kind-hearted old lady of Olathe, Kansas, remembered him to the extent of $66,500 in her will. This is the first case on record where a man has been rewarded in the will of one of his radio listeners.

Five Pointers for Reducing Static

1: NEARBY signals, when we have the advantage of a relatively high signal level as compared with the static level, are fairly free from static. Good reception is therefore assured from nearby broadcasting stations, especially today when many of the broadcasters have gone to higher powers so as to insure proper reception of programs under all conditions.

2: THE most effective way of reducing static is to select a powerful radio signal—which usually means a local station. Ordinarily, there will be no static interference in the first place; but if the background is scratchy and blurred as the result of intense static, the output volume of the set can be cut down until the background noises are reduced to the vanishing point. Obviously, the signal volume is also reduced, but if it is sufficiently powerful to begin with, there is ample opportunity for reducing it and still have left sufficient volume at the end.

3: WHEN static interference is excessively troublesome, the amplification should be cut down to one stage. In the event that static interference is overwhelmingly troublesome (such as with an approaching thunderstorm) it is still possible to listen to sufficiently powerful signals by means of the head-set, without amplification of any kind.

4: LOUDSPEAKER reproduction often may be improved in summertime reception by bridging a small fixed condenser across the loudspeaker terminals. The capacity of such a condenser obviously must vary from one type of loudspeaker to another, but a little experimentation with several sizes of small fixed condensers must soon disclose the proper value for a loudspeaker.

5: IT is hardly necessary to go to the trouble of installing a shorter antenna for summertime operation, although the radio listener will obtain interesting results by trying out various kinds of antennas. After all, the only result of a short antenna or an indoor antenna is that the amount of energy intercepted is noticeably less than with a full-sized antenna; hence the static level falls and with it falls the signal level. If the static level is below the signal level to begin with, this matter of dropping the initial values to lower levels must bring the low static down below the threshold of audibility. At best it is an illusion, though to some it is highly pleasing.

—DR. ALFRED N. GOLDSMITH

WHAT'S NEW IN RADIO APPARATUS

THIS *department is conducted by* POPULAR RADIO LABORATORY *for the purpose of keeping the radio experimenter and the broadcast listener informed concerning the newest inventions and the approved developments in radio equipment. Only such apparatus as has been tested and endorsed by the Laboratory is noted in these columns.*

AERIALS

Super-Sensitive Omni-Directional aerial: Portable Globe Aerial Co.

AUDIO-FREQUENCY TRANSFORMERS

Pacent audioformers; Pacent Electric Co., Inc.
Peerless Twin-audio; Peerless Radio Corp.
Precise audio-frequency transformer; Precise Mfg. Co.
Precise push-pull transformers; Precise Mfg. Co.
"Hegehog" audio-frequency transformer; Premier Electric Co.
"Receptrad" audio-frequency transformer; Radio Receptor Co.
Reliable audio-frequency transformer; Reliable Parts Mfg. Co.
"Rhamstine" audio-frequency transformer; J. Thomas Rhamstine.
"Rubicon" audio-frequency transformer; Rubicon Co.
Duplex (push-pull) transformer; Rubicon Co.

BATTERIES

Prest-O-Lite batteries; Prest-O-Lite Co., Inc.
Jumbo battery; Primary Mfg. Corp.
"Rebat" rechargeable wet "B" batteries; Radio Rebat Co.

BATTERY CHARGERS AND RECTIFIERS

"Rhamstine" "B" rectifier; J. Thomas Rhamstine.
Battery chargers; P. C. Rumbold

CRYSTAL DETECTORS

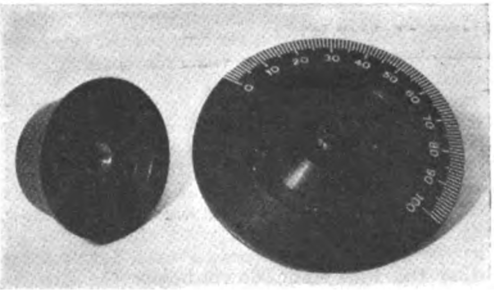
Oscillaformer; Oscillaformer Co.
Detector stand; Pacent Electric Co., Inc.
"Death Valley" crystal; Pacific Radio Specialty Co.
"Death Valley" permatect; Pacific Radio Specialty Co.
De-Tec-Tone crystal detector; Pyramid Products Co.
Big Pyramid crystal; Pyramid Products Co.
Goldwhisker; Rep Radio Co.
Roll-O crystal; Roll-O Crystal Co.
R-U-F semi-fixed detector; R-U-F Products Co.
R-U-F rough wonder crystal; R-U-F Products Co.
Rusonite fixed detector; Rusonite Products Corp.

DIALS

Ultra-vernier tuning control; Phoenix Radio Corp.
"Hemco" dials; Geo. Richards & Co., Inc.

GRID-LEAKS AND RESISTANCES

Cartridge resistances; Pacent Electric Co., Inc.
Grid-leak and condenser; Pfanstiehl Co.
Nonoise variable grid-lead; Radio Foundation, Inc.



A dial made in two parts that is self-centered.

THE DIAL WITHOUT A SET-SCREW

Name of instrument: Knob and dial.
Description: This knob and dial unit is made in two pieces and is attached to the shaft of a tuning instrument by means of a threaded chuck. The dial itself is placed over the shaft in the right position and then the small knob is screwed up tight causing the chuck to pinch on the shaft, thus making a secure and self-centered fit.
Usage: As a dial for tuning a radio-frequency circuit.
Outstanding features: Neat appearance. Clear vision of the numerals. Self-centering. No set-screws. No wobbling.
Maker: Waterbury Button Co.

HEADPHONES

"Pacent" headsets; Pacent Electric Co., Inc.
"Perfectone" phone; Perfectone Radio Corp.
"Randolph" special headphone; Randolph Radio Corp.
"Royalfone" headset; Royal Electrical Laboratories.

JACKS

Pacent jacks; Pacent Electric Co., Inc.

KITS

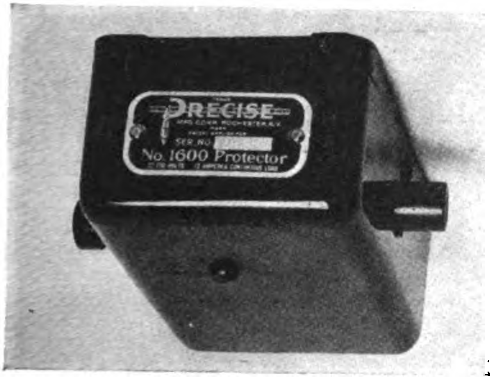
Ultradyne kit; Phoenix Radio Corp.
Pink-A-Tone superheterodyne kit; Pinkerton Radio Corp.
"Vir Bren" kit; Radio Instrument Co.
"Raven" superheterodyne kit; Raven Radio, Inc.
"Rubicon" kit; Rubicon Co.

LIGHTNING ARRESTERS

Anchor lightning arrester; Radio Receptor Co.

LOOPS

"Pathe" Curtentenna; Pathe Phonograph & Radio Corp.
"Pollard" loop; Pollard Bros.
Collapsible loop aerial; Radio Association of America
Duo-Spiral folding loop; Radio Units, Inc.
"Hemco" loop aerial; Geo. Rchards & Co., Inc.
"Ritter" loop aerial; Ritter Radio Corp.



An automatic switch that prevents short-circuits.

A BATTERY CIRCUIT BREAKER

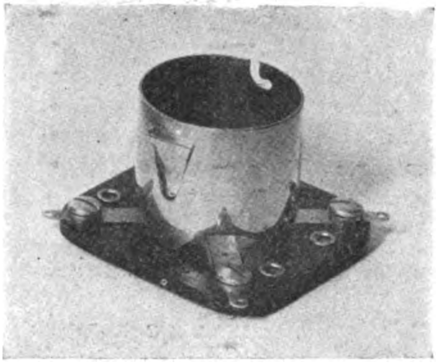
Name of instrument: Circuit breaker.

Description: A protective switch enclosed in a neat metal container for mounting near the storage battery of a receiving set, to protect the battery and the set against short-circuits. The breaker may be set in operation by pressing one of the small buttons. The other one if pressed will release the switch and open the circuit. If a short-circuit occurs the switch automatically opens and stays open until it is reset by the operator. The mechanism may be set to open at a load of three or four times that drawn by the filaments of the vacuum tubes in the receiver.

Usage: As a protective switch against short-circuits in a radio installation.

Outstanding features: Absolute protection. Small size. Ease of setting.

Maker: Precise Mfg. Corp.



A low capacity is obtained between terminals.

AN EFFICIENT VACUUM-TUBE SOCKET

Name of instrument: Vacuum-tube socket.

Description: This instrument is about as simple as it is possible for it to be. The contact pieces are attached to the skeleton insulator base by screws which can be used for fastening connecting wires. The contact, however, is also brought out in a single piece which is available for soldering. The tubular support for the vacuum tube contains a unique flap for applying pressure on the side of the tube and thus holding it secure in the socket. The four eyelets are installed in the base for mounting.

Usage: As a holder for vacuum tubes in a receiving set.

Outstanding features: Light weight. Good contact. Low capacity between terminals. High insulation. Neat appearance.

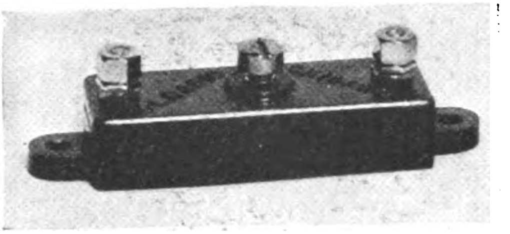
Maker: Leich Electric Co.

LOUDSPEAKERS

"O'Neil" audiphone; O'Neil Mfg. Co.
"Pathe" loudspeaker; Pathe Phonograph & Radio Corp.
"Perfectone" loudspeaker; Perfectone Radio Corp.
"Radiola" loudspeaker; Radio Corporation of America
Radio Vase; Radio Vase Co.
American Bell loudspeaker; Randolph Radio Corp.
"Thorola" loudspeaker; Reichmann Co.
"Thorophone" loudspeaker; Reichmann Co.
"Remo" Trumpet; Remo Corporation
"Remola" recreator; Remo Corp.
"Royalfone" loudspeaker; Royal Electrical Laboratories

MISCELLANEOUS ACCESSORIES

Radio wall map; Ozarka, Inc.
Peerless Twin-audio amplifier; Peerless Radio Corp.
"Nodust" cleaner; Peiffer & Co.
"PRSH" A. C. leads; Pittsburgh Radio Supply House
Standard adjustable aerial base; Pomona Hardware Co.
Panel engraving machine; H. P. Preis & Co.
"Precise" No. 1,600 protector (circuit breaker); Precise Mfg. Corp.
Filtoformer; Precise Mfg. Co.
Coil plug receptacle; Pacent Electric Co., Inc.
Jack name plates; Pacent Electric Co., Inc.
Quinby radio frames; Quinby Radio Frame Corp.
"Radeco" safety fuses; Radio Equipment Co.



A small condenser provided with an adjusting screw that is a great aid in neutralizing a receiver.

A SMALL ADJUSTABLE CONDENSER

Name of instrument: Small variable condenser.

Description: The two plates which form part of this condenser are mounted inside of the neat bakelite container directly on the two screw terminals shown and also serve as binding-post terminals. The adjustable screw in the center when turned in a clockwise direction depresses one of the plates, thus decreasing the distance between them and increasing the capacity.

Usage: In any part of an electric circuit where a very small variable condenser is necessary.

Outstanding features: Small size. Electrical efficiency. Exactness of manufacture. Ease of adjustment. Neat appearance.

Maker: X-L Radio Laboratories.

"Run-a-Radio"; Radio Appliance Co., Inc.
Tiny-Turn vernier control; Radio Units, Inc.
"Rajah" snap terminals; Rajah Auto Supply Co.
"Rajah" radiator ground; Rajah Auto Supply Co.
Goldwhisker; Rep Radio Co.

PANELS

Panelyte radio panels; Panelyte Board Co., Inc.
Insuline radio panels; Radio Panel & Parts Corp.

PHONE PLUGS

Plugs; Pacent Electric Co., Inc.
Poly plug; Polymet Mfg. Corp.

PHONOGRAPH ATTACHMENTS

Phonograph attachment; Perfectone Radio Corp.
"Thorola" phonograph attachment; Reichmann Co.
"Rhamstine" victophone; J. Thomas Rhamstine
"Rhamstine" needlephone; J. Thomas Rhamstine
"Royalfone" unit; Royal Electrical Laboratories

POTENTIOMETERS

No. 88 potentiometer; Pacent Electric Co., Inc.
"Premier" potentiometers; Premier Electric Co.

POWER AMPLIFIERS

"Radiola" balanced amplifier (push-pull); Radio Corporation of America.

RADIO CABINETS

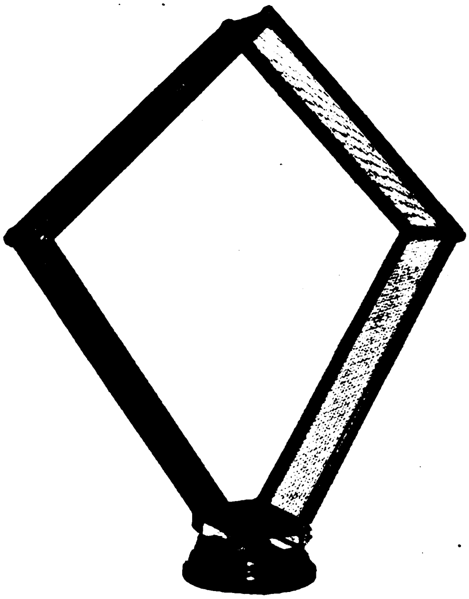
"Campbell" radio cabinet; Perkins-Campbell Co.
Radio cabinets (desk style); Peters Electric Cabinet Co.
"Robbins" radio desk; Robbins Woodworking Co.

RADIO FREQUENCY TRANSFORMERS

Ultraformer; Phoenix Radio Corp.
Pink-A-Tone transformer; Pinkerton Radio Corp.
Super-multiformer; Precise Mfg. Co.
Precision radio-frequency transformer; Precision Coil Co., Inc.
"Vir Bren" radio-frequency transformers; Radio Instrument Co.
"Vir Bren" input transformer; Radio Instrument Co.
"Reliable" radio-frequency transformer; Reliable Parts Mfg. Co.
Intermediate-frequency transformer; Reliable Radio Mfg. Co.
Intermediate-frequency transformer; Remler Radio Mfg. Co.
"Rubicon" radio-frequency transformer; Rubicon Co.
Tuned stage transformer; Remler Radio Mfg. Co.

RECEIVING SETS

"Operadio" receiver; Operadio Corp.
Low-wave receiving set (for amateurs); Ott Radio, Inc.
"Ozarka" portable receiver; Ozarka, Inc.
"Ozarka" 4-tube set; Ozarka, Inc.
"Minute Man" receiving set; Pathe Phonograph & Radio Corp.



This loop is jointed in five places, which permits folding into a very compact unit.

A COLLAPSIBLE LOOP

Name of instrument: Loop antenna.

Description: A portable loop with a unique folding feature. The wooden strips which support the five slotted insulator rods are hinged so that they may be folded up. The two upper sections thus may be inverted and the two lower sections may be closed up vertically, reducing the over-all dimensions to a small space for packing. The wires, however, remain taut in any position of the outer frame. The loop itself may be revolved on a fixed base.

Usage: As a pick-up device for a radio-frequency receiver.

Outstanding features: Portability. Neat workmanship. Good appearance. Variable inductance. Directional efficiency.

Maker: Aalco Radio Laboratories, Inc.

"Penn-C" Selectedyne receiver; Pennsylvania Wireless Mfg. Co.
"Ultradyne" receiver; Phoenix Radio Corp.
"McCullough" AC receiver; Pittsburgh Radio Supply House
"S-P-Z" receiver; Pittsburgh Radio Supply House
"Ace" receiver; Precision Equipment Co.
"Radiola" receivers; Radio Corporation of America.
R-212 receivers; Radio Service Laboratories.
"Echophone" receivers; Radio Shop.
"Randolph" 5-tube set; Randolph Radio Corp.
"Tone-A-Dyne" receiver; Resas, Inc.
"Richardson-5" receiver; Richardson Radio, Inc.
"Ritter" crystal receiver; Ritter Radio Corp.

SOCKETS AND ADAPTERS

Pacent sockets; Pacent Electric Co., Inc.
Pacent adapters; Pacent Electric Co., Inc.
Bakelite socket; Pioneer Radio Corp.
"Lo Loss" tube socket; Premier Electric Co.
Ballgrip bakelite socket; Quality Molded Products, Inc.
Socket; Remler Radio Mfg. Co.
"Remco" socket; Geo. Richards & Co., Inc.

SWITCHES

"Precise" No. 1,600 Protector (circuit breaker); Precise Mfg. Co.

TESTING INSTRUMENTS

"Reliable" battery tester; Reliable Parts Mfg. Co.

TUBES

O-T "Silvertone" tube; O & T Electric Corp.
Amplitron vacuum tube; Pennant Radio Laboratories.
"Ceco" vacuum tubes; Providence Distributing Co.
Radiotron tubes; Radio Corporation of America.
Ravac tube; Ravac Company, Inc.
Atlas tube; R-S-K Co.

TUNING INDUCTANCE UNITS

Duolateral coils; Pacent Electric Co. Inc.
Phusiformer; Pathe Phonograph & Radio Corp.
"Pearlco" variocoupler; Pearl Radio Corp.
"Pearlco" variometer; Pearl Radio Corp.
Low-loss supercoil; Perfection Radio Mfg. Co.
Three circuit tuner; Pfanstiehl Radio Co.
Variometer; Pfanstiehl Radio Co.
Inductance for Reinartz circuit; Pfanstiehl Radio Co.
Pink-A-Tone oscillator coupler; Pfanstiehl Radio Co.
"Pioneer" variometer; Pioneer Radio Corp.
"Pioneer" variocoupler; Pioneer Radio Corp.
Precision Cockaday coils; Precision Coil Co., Inc.
Precision R. F. coupling unit; Precision Coil Co., Inc.
Precision autodyne coil; Precision Coil Co., Inc.
"Vir Bren" oscillator coil; Radio Instrument Co.
"Vir Bren" antenna coil; Radio Instrument Co.
"R. P. C." variometer; Radio Products Co.
"R. P. C." variocoupler; Radio Products Co.
"Receptrad" filter coupler; Radio Receptor Co.
Andrews paddle wheel coil; Radio Units, Inc.
"'Thorola" low-loss doughnut coil; Reichmann Co.
Coupling unit; Remler Radio Mfg. Co.
RBC-KM filter, oscillator-coupler and transformer; Rieger-Bailey Co. of America, Inc.
Variometer; Ritter Radio Corp.

TOOLS AND EQUIPMENT

Radio tool set; Perry-Fay Co.
Metalectric soldering iron; Post Electric Co.
Rance combination radio pliers; Rance Corp.
"Rhamstine" electric solder set; J. Thomas Rhamstine

VARIABLE CONDENSERS

Variable condensers; Pacent Electric Co., Inc.
Variable condenser with vernier; Pearl Radio Corp.
Ultra low-loss condenser; Phoenix Radio Corp.
"Crofoot" variable condenser; Premier Electric Co.

This unit added to a receiver will prevent radiation, increase selectivity and the volume.

A NEUTRALIZED RADIO-FREQUENCY AMPLIFIER UNIT

Name of instrument: Radio-frequency amplifier.

Description: This instrument, which is commercially known as the "Penetrola," consists of one stage of neutralized radio-frequency amplification which uses the Isofarad circuit. The tuning for this receiver is done by the large knob above on the face of the metal cabinet. The smaller lower knob controls the filament while the knob at the left adjusts the neutralizing condenser. This unit may be attached directly to any type of receiving set—regenerative or non-regenerative—and will increase the range of the receiver to which it is attached as well as sharpen the tuning and prevent radiation. It may be used with a short or a long antenna and the connections are provided in cable form.

Usage: With any radio receiving set as an additional stage of radio-frequency amplification.

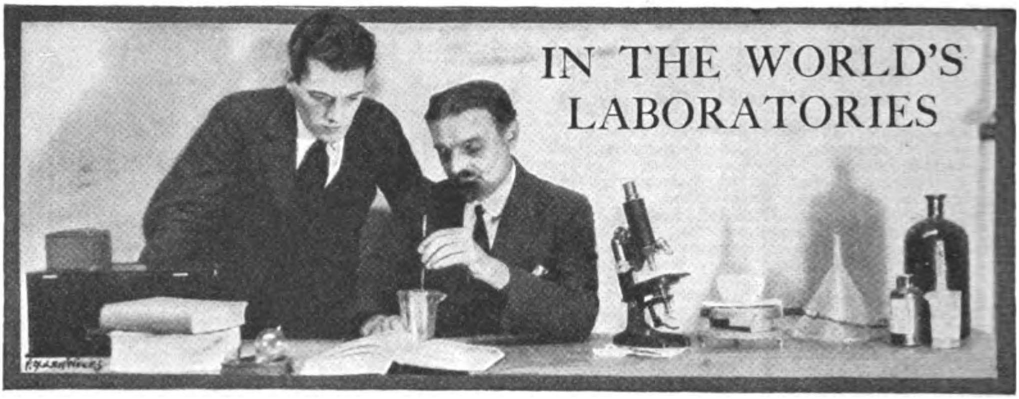
Outstanding features: Novel circuit design. Good workmanship. Ease of operation. Non-radiating. High efficiency.

Maker: Walbert Mfg. Co.

"R. P. C." variable condenser; Radio Products Co.
Microdenser; Radio Shop
"Straightline" condensers; Radio Stores Corp.
"Rathbun" condenser; Rathbun Mfg. Co., Inc.
"Reliable" neutralizing condenser; Reliable Parts Mfg. Co.
"Reliable" micro air condenser; Reliable Parts Mfg. Co.
Variable condenser; Remler Radio Mfg. Co.

WIRE

Loop wires; Ross Antenna Co.
Litz wires; Ross Antenna Co.
Cotton-covered wire; Ross Antenna Co.



IN THE WORLD'S LABORATORIES

CONDUCTED BY DR. E. E. FREE

The Ether and the Soul

SIR OLIVER LODGE is one of the world's most competent and sensible scientific investigators. He is also, as newspaper readers well know, one of the few scientific men who have accepted the beliefs of the spiritualists. He not only admits a *possibility* that there exist non-material forces and actions and even beings, but he believes all these things to be *facts*. He has devoted much work to the field of psychic research. He is convinced that human personalities survive after the dissolution which we call death.

Unusual interest attaches, therefore, to a recent radio address made by Sir Oliver from 2LO, in London, in which he suggests that the mysterious ether, about which there has been so much argument, may be the seat of psychic forces and entities as well as the medium for the transmission of radio waves and of light.*

It is possible, Sir Oliver thinks, that life may be connected much more intimately and permanently with the ether than with matter. The ether has "perfect properties." No energy is lost when light (for example) traverses it. Matter, on the other hand, is liable to deterioration. Energy is lost in it and by it. Matter becomes the seat of the mysterious forces which we call life. Matter becomes "animated." The question arises, can ether be animated too?

All force, Sir Oliver continued, is exerted through the ether. It is the medium of such life attributes as mind and memory. These attributes belong to the part of the universe which is unseen. If they have contacts with physical things at all, those contacts are presumably through the ether. Our material bodies are transient. They wear out. Mind, too may need a vehicle, one that is independent of the body and of matter. The present connection of life with matter is probably, Sir Oliver thinks, neither permanent nor direct. The real medium of the life force is ether.

Undeniably these speculations are interesting. Sir Oliver always contrives to be that. Whether, in the present state of knowledge, they get us much farther in the progress of thinking, is another question. The ether itself is, admittedly, utterly mysterious. The life-force or soul or whatever you want to call it is equally mysterious. It does not seem so very useful, therefore, to equate the two mysteries.

Still, most people demand to be allowed to think about the soul. They might as well think about an etheric soul as any other kind. No one can say that they are wrong—or right.

New Antenna System Reduces Static

AN ingenious application of two loop antennas to the problems of directive reception and of static reduction has been perfected by Mr. H. T. Friis of the Bell Telephone Laboratories and was described by him recently before the Institute of Radio Engineers, in New York City.*

The device consists of a long structure, like the movable part of a rotating drawbridge. It rotatess, too, just as the drawbridge does, but on wheels at the two ends instead of on a central pivot. At the two ends of the structure are the two loops, the length of the "bridge" being such that these loops are distant from each other just 1/12 of the wavelength that is to be received. For example, for receiving a 600-meter wave, the length of the bridge between the two loops is 50 meters, approximately 150 feet.

---

*The address was the last of a series of seven broadcast by Sir Oliver under the title "Ether and Reality." It was delivered on March 31, 1925, and was reported in the London press and in *Nature* (London), vol. 115, page 505 (April 4, 1925). In another address in Christ Church, London, on March 12, 1925, Sir Oliver expressed somewhat the same ideas. This address is reported in the *Chemical News* (London), vol. 130, page 199 (March 27, 1925).

*Mr. Friis' paper was presented before the Institute of Radio Engineers on May 6, 1925. It was reported in the Radio Section of the New York Herald-Tribune on May 10, 1925. The facts given here are taken from a statement issued by the Bell Telephone Laboratories, Inc., New York City.

The operation of the apparatus depends on the fact that radio waves need time to move through space. If one end of the bridge is pointed directly toward the transmitting station the loop at that end of the bridge will receive the wave first. The loop at the other end of the bridge receives the wave a little later. If the two loops are 1/12 wavelength apart this will mean that the received wave in the second loop will be 1/12 later in phase than the wave in the first loop. Expressed in the usual fashion, this means that the second wave will be 30 degrees out of phase with the first.

The next step is to shift this phase difference still further by means of a phase-changer attached to the receiver. It is shifted, in fact, 150 degrees, which makes it just 180 degrees out. This means that the wave coming from that direction will actuate the two loops in exactly opposite fashion. They will cancel each other. Nothing will be heard in the receiver.

But consider a wave coming from the opposite direction. This wave will encounter the two loops in the reverse order. The 30-degree phase lag will apply in the reverse direction to the 150-degree phase difference produced by the phase changer. Accordingly, the net, or resultant, difference in phase between the two loops will be 120 degrees, instead of 180 degrees. This means, as any electrical engineer will tell you, that the signal strength is not canceled. In fact, it is left unimpaired. The two loops function as though they were a single loop or any other satisfactory type of antenna.

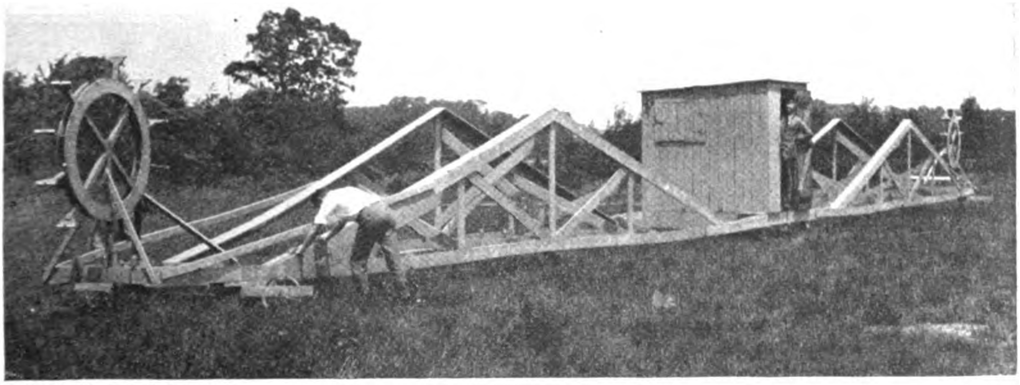
The net effect is, then, that signals coming toward one end of the bridge are received perfectly, while signals approaching toward the other end of the bridge are not received at all. This gives us a directional antenna which will receive from any direction lying in one semicircle and not at all from any direction lying in the opposite semicircle. The ordinary directional loops are much less effective than this, since they receive reasonably well from any direction except those within a narrow angle nearly perpendicular to the plane of the loop.

This is why Mr. Friis' device is so effective in reducing static. Most of the static is directional. If the bridge is pointed in any direction in the semicircle opposite to the direction of the static, the static will be canceled out and will not be heard. Any desired signal coming from the proper semicircle will be heard unimpaired. In the actual set-up used by Mr. Friis a superheterodyne receiver was employed, and the precise tuning of this receiver enabled a still further reduction of the static.

The chief disadvantage of the apparatus is the length, cost and cumbersomeness of the movable bridge carrying the two loops. But doubtless this can be reduced. One thinks, for example, of a pair of very light loops mounted on the two ends of a long pole or a duralumin girder and balanced on the top of a tall vertical pole, like the weathercock on a steeple.

Earth Conductivity Affects Inclination of Radio Wave

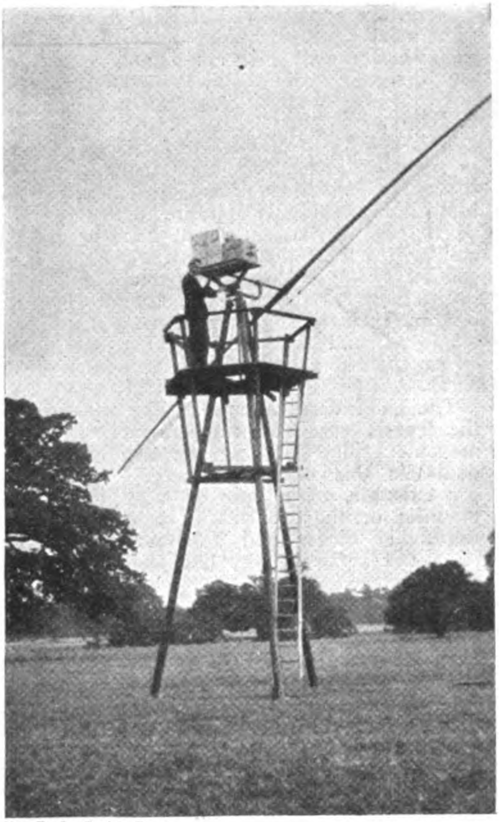
Most of the modern theories of radio transmission assume that one component of the wave arriving at a distant receiving station has reached there by some path high up in the air, as, for example, along the supposed Heaviside Layer. If this be true this component of the wave ought to arrive at the receiver with a downward inclination, its wavefront being not quite perpendicular to the surface of the ground. A mechanical analogy is



Bell Telephone Laboratories

A NEW ANTENNA SYSTEM FOR DIRECTIVE RECEPTION

This rotating bridge, having loop antennas at both of its ends, has been built by Mr. H. T. Friis to obtain more complete directive reception as well as to reduce static. The system receives signals from any direction in one semicircle, but from no direction in the opposite semicircle.



Dr. R. L. Smith-Rose

MEASURING ELECTRIC FIELDS

This straight-wire antenna, or "Hertzian rod," was used by Dr. Smith-Rose to determine the direction of the electric field of an arriving radio wave.

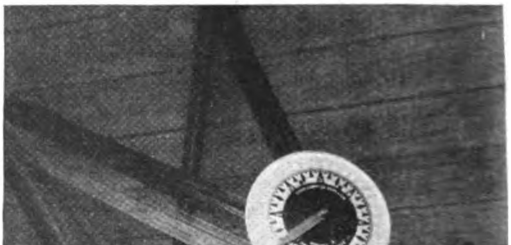
the artillery shell which is fired at a high angle of elevation, reaches the higher levels of the atmosphere during its flight, and finally arrives at its target along a downward-pointing path as though it were falling obliquely from the clouds.

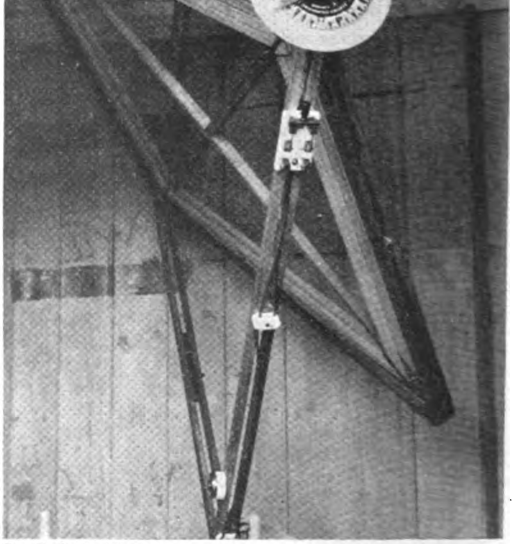
The well-known English radio engineers, Dr. Smith-Rose and Mr. Barfield, have now attempted to verify this theory by a direct test of the inclination of the wavefront arriving at a receiving station.* This proved to be impossible practically because of the relatively high conductivity of the earth's surface. For a perfectly-conducting earth the electric force is always vertical and the magnetic force always horizontal regardless of the real inclination of the wavefront of the arriving wave.

Experimental tests of the actual conductivity of the earth at a number of localities in England showed values between 6 x 10^8 and 4.7 x 10^8 electrostatic units. The higher of these values is equivalent, roughly, to 800 ohms resistance per cubic inch of soil. The measurements were made at radio frequencies, by observing the forward tilt of waves from a nearby transmitter.

These conductivities are relatively high for materials of the insulator class and this is ascribed to the fact that the soil and rocks of England are prevailingly moist. This suggests a possible research for radio engineers who happen to be located in some of the American desert regions. In large parts of California, Nevada, Arizona and other western states the soil is almost waterless. Its conductivity is probably far lower than the values found by Dr. Smith-Rose and Mr. Barfield in England. The repetition of these experiments in some such locality might yield very useful information about the actual paths of radio waves close to the earth.

The research is not to be recommended, however, to the amateur or to any one except a well-trained and experienced radio engineer. The necessary technique involves the determi-





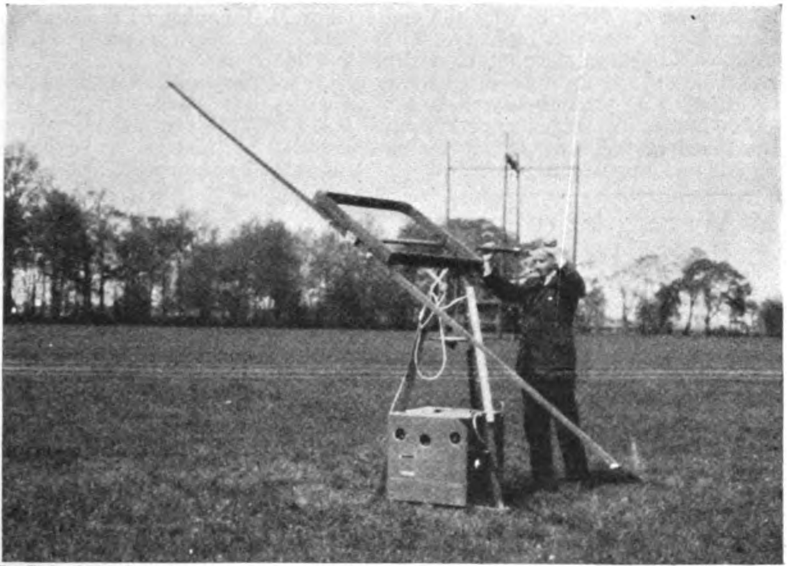
Dr. R. L. Smith-Rose

THE TILTING LOOP

This device determined the direction of the magnetic field of the arriving wave. The intensity of the signal varied with the position of the loop relative to the wave.

---

*"On the Determination of the Direction of the Forces in Wireless Waves at the Earth's Surface," by R. L. Smith-Rose, Ph.D., and R. H. Barfield. *Proceedings of the Royal Society* (London), Series A, vol. 107, pages 587-601 (March 2, 1925).



Dr. R. L. Smith-Rose

THE COMPLETE APPARATUS FOR MEASURING WAVE INCLINATION
This portable apparatus, being operated by Dr. Smith-Rose, combines the Hertzian rod and the tilting magnetic loop shown on the preceding page. Measurements with this apparatus led to a determination of the prevailing electrical conductivity of the soil in England.

nation of the direction of the electrostatic field by a Hertzian rod—practically a straight, single-wire antenna the inclination of which can be varied—and the exploring of the electromagnetic field by means of a tilting loop. Both of these pieces of apparatus will work usefully only in the hands of experts, who know exactly what they are about.

Surface Films as Radio Detectors

WHATEVER be the secret of the detecting action of a crystal, it is reasonably certain that this action is accomplished within a thin film, possibly some scores of atoms deep, on the surface of the crystal. The main body of the crystal serves merely to support this surface film. It has no more to do with the detecting action than the main structure of a house has to do with the paint on its roof.

Why not make use, then, of a mere film of crystal material, of lead sulphide (which is the same as galena) or of silver sulphide or of something else? That this can be done with considerable success is claimed by Mr. James Strachan,* whose work on various phases of crystal detection is already familiar to readers of this department.

Mr. Strachan reports, for example, that a piece of lead, a piece of silver or a piece of copper may be exposed to moist sulphuretted hydrogen gas (which is the gas of rotten eggs) and will acquire a thin film of the respective sulphide, which film is then quite efficient as a detector. It works best, he reports, when used with an applied potential. Similar effects may be obtained with oxide films on copper or brass. The mere tarnish which forms naturally in the air on brass articles and which consists, usually, of mixed oxides and sulphides of copper and zinc, will serve quite well for radio detection.

These film detectors are worthy of more attention from experimenters than they seem to have had hitherto.

How to Repair a Broken Lead Wire

A HINT of real value for those who experiment with vacuum tubes is contained in a recent note by Mr. D. A. Wells of the University of Cincinnati.* When one of the fine wires that enters through the glass of an experimental tube is broken off outside the glass, as is all too frequently the case, it is usually believed necessary to throw the tube away. Soldering a new wire to the tiny projecting point of metal is ordinarily a hopeless task.

Mr. Wells uses, he reports, a contact consisting of a drop of metallic mercury. First he cleans the broken, projecting point of the wire with a drop of nitric acid. Then he places a

---

*"Some Interesting Experiments with Single-Point Detectors," by James Strachan. *Wireless World* (London), vol. 15, pages 200-202 (November 12, 1924).

*"Method of Repairing Broken-off Lead-in Wires," by D. A. Wells, *Journal of the Optical Society of America* (Menasha, Wis.), vol. 10, pages 615-616 (May, 1925).

drop of mercury on it. Next he dips the end of a clean copper wire into this mercury. The copper wire must be held in place mechanically by a strip of tape around the tube or in some other way. Electrically, the mercury contact is good enough. Many a damaged experimental tube can be saved in this way, thus avoiding the blowing and pumping of a new tube.

Radio Wave Absorption by Berlin Houses

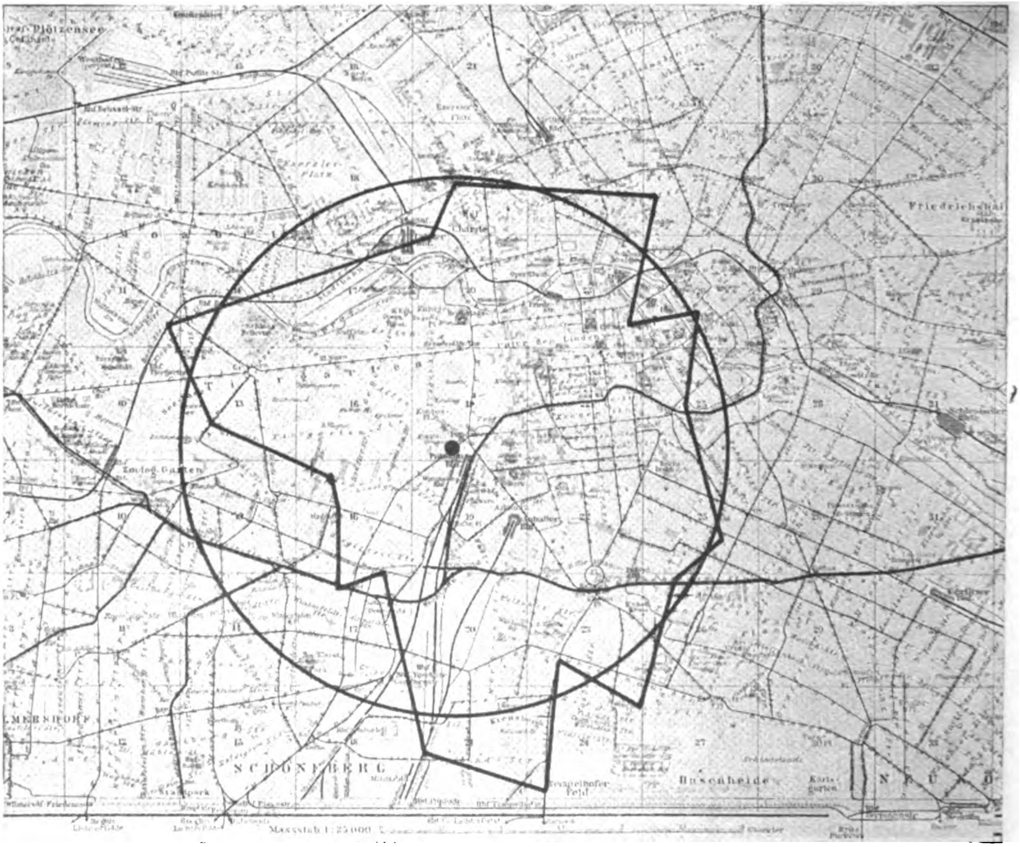
Over a year ago the engineers of WEAF made a series of measurements of the strength of signals from their station at numerous points on and near Manhattan Island and prepared a map showing in most interesting fashion just how the signals were affected by the two rivers and by the blocks of tall steel buildings in the downtown and the Forty-second Street districts of the city. A similar investigation has now been made by Postal Councillor M. Bäumler, of the German Government Telegraph Service, for the cities of Berlin and Hamburg.*

As was expected, Herr Bäumler found determinable irregularities in the strength of the fields in different directions from the transmitter. Perhaps the most interesting feature disclosed by the map of Berlin is the fact that transmission was better over the famous Tiergarten park than in directions where the city is closely built up. Buildings are evidently more absorptive than trees, at least under the conditions of these tests.

As was the case in New York, no actual "dead spots" were found. We hear less of these supposed dead spots nowadays in the United States, but London is going through an epidemic of them. The London broadcast-

---

*The results are reported in "Elektrische Nachrichten-Technik," vol. 1, part 5, published by the Wiedemannsche Buchhandlung, Berlin, and are abstracted (in German) in *Der Funker* (Berlin), vol. 4, pages 17-19 (February, 1925).



Redrawn from "Der Funker"

HOW THE CITY OF BERLIN AFFECTED RADIO WAVES

The black dot at the center shows the location of the transmitter at Voxhaus. The circle indicates a uniform distance from this transmitter. The other line connects points at which the same signal strength was found. Note that the transmission is good toward the westnorthwest, over the great park marked "Tiergarten."

From a photograph made for POPULAR RADIO

HOW DEAF STUDENTS CAN LEARN TELEGRAPHY

The "touch receiver" invented by Mr. Jakosky and his associates is worn by the man at the right. Mr. Jakosky himself is at the key. At his left are Dr. McConnell, of the Bureau of Mines, and Mr. Ingel of the Western Pennsylvania School for the Deaf. The type of receiver designed for reception by the finger tips may be seen on the table.

ing station, 2LO, was moved recently to a new location. Since then there has been much complaint that the southeastern portion of the city is so shielded that the programs cannot be received.

Long Waves Also for MacMillan

THE MacMillan Arctic Expedition, which sailed recently for its winter vigil in the north, was originally designed to be equipped only with short-wave radio, the experiences of the last expedition having convinced the officials of the American Radio Relay League that the best results would be attained with waves shorter than one hundred meters.

But this is not to be. The United States Navy is contributing to the expedition some airplanes and equipment together with fliers to operate them. The Navy insisted that the expedition carry regulation long-wave radio apparatus, it being the Government opinion that these more usual wavelengths were more surely dependable than the newer short ones.

And so, if newspaper reports are to be trusted, the expedition will be equipped with both short-wave and long-wave transmitters and receivers. Assuming that space for both is available, this is an admirable outcome. The expedition should come back with much data pertinent to the controversy between advocates of short waves and low power and advocates of long waves and high power.

Receiving Radio Code by Touch

AMONG professions lately made available to deaf persons is, curiously enough, the profession of telegraph operator. This has been done by the perfection of a code receiver which operates by touch instead of by hearing. The device can be applied to radio code as well as to the Morse code of land telegraph lines. There is no reason, therefore, why deaf persons cannot now enjoy code conversations by radio or even, it may be possible, seek employment as commercial radio operators.

The new touch receiver has been devised by Mr. J. J. Jakosky, well-known radio engineer of the United States Bureau of Mines, in cooperation with Dr. W. J. McConnell, a surgeon of the Bureau of Mines, and Mr. Truman L. Ingle, Principal in the Western Pennsylvania School for the Deaf.* Two forms have been perfected; one operating through the finger tips, the other by means of a small plate held against the temple, as the telephone receivers worn by switchboard operators are held against the ear.

In both cases the line is actuated with ordinary 60-cycle alternating current. Attached to the "sounder" or receiving device on this line is a vibrating armature designed to respond by vigorous vibration to this 60-cycle current. In the finger-tip apparatus this armature is attached to a small metal plate against which the fingers are placed. In the head-band form of the apparatus a similar metal plate presses against the skin of the temple.

---

*"Telegraphy for the Deaf," by J. J. Jakosky, W. J. McConnell and Truman L. Ingle, a pamphlet printed by the Class in Printing at The Western Pennsylvania School for the Deaf, Englewood, Pittsburgh, Penna., 1925. 7 pages.

Pressing the key at the sending end of the line sends the alternating current into the receiver, sets the vibrating plate into motion and makes the quivering of this plate perceptible to the deaf "listener" at the receiving end. Dots and dashes are distinguishable by length, just as in the usual audible receivers. Weak impulses from long lines are fed into relays and converted into the alternating-current local signal, just as telegraph signals are now reinforced by using direct-current relays. Radio signals may be converted and made sensible to touch in the same way.

Two Important Experiments on the Ether and Relativity

THE famous Einstein theory was developed, you remember, partly from a remarkable experiment known as the Michelson-Morley experiment. This experiment had for its object the detection of any possible motion of the earth with relation to the ether, this being ascribable, of course, to the motion of the earth in its orbit or to its rotation on its axis.

The experiment failed. No drift of ether through or past the earth was detected. There were three possible explanations: (1) that there is no ether, (2) that an ether exists but moves with the earth, (3) that the motion of the earth relative to the ether is exactly compensated by a contraction of matter in this direction, just as a wind blowing against a gas-filled balloon will cause it to contract a little in the direction of the wind pressure. The Einstein theory is consistent with either the first explanation or the third.

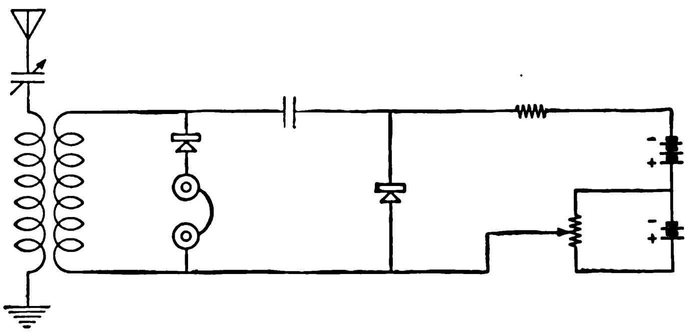
Two recent experimenters have carried out tests essentially analogous to the famous Michelson-Morley one. The results were announced at the recent meeting of the National Academy of Sciences in Washington and constitute some of the most important scientific data that we are likely to acquire this year.

One of the experiments was devised by the same Professor Albert A. Michelson who helped conduct the original Michelson-Morley experiment. In a field some ten miles west of Chicago, Professor Michelson built a square of iron pipe approximately one mile on a side. He pumped most of the air out of this pipe so that accidental variations of the temperature or pressure of the air inside the pipe would not affect the experiment. Then he sent two light rays around the square of pipe; one ray in one direction, the other in the opposite direction.

Meanwhile the earth was revolving, carrying the pipe square with it. The light ray that moved in one direction through the pipe was moving, on the average, with the rotation of the earth. The ray in the opposite direction was moving against the earth's motion. Accordingly any "ether drift" should cause one ray to complete the circuit a trifle faster than the other one.

A long series of very exact measurements was carried out. No ether drift was detected. The result agrees, therefore, with that of the earlier Michelson-Morley experiment and is consistent with the Einstein theory of relativity.*

The other experiment was carried out by Professor Dayton C. Miller, of the Case School of Applied Science, of Cleveland. He too repeated an experiment essentially similar to the Michelson-Morley experiment, but he did it on top of Mt. Wilson, in California, where the great astronomical observatory is situated. His results are absolutely contrary to those of Professor Michelson. He finds a drift of the

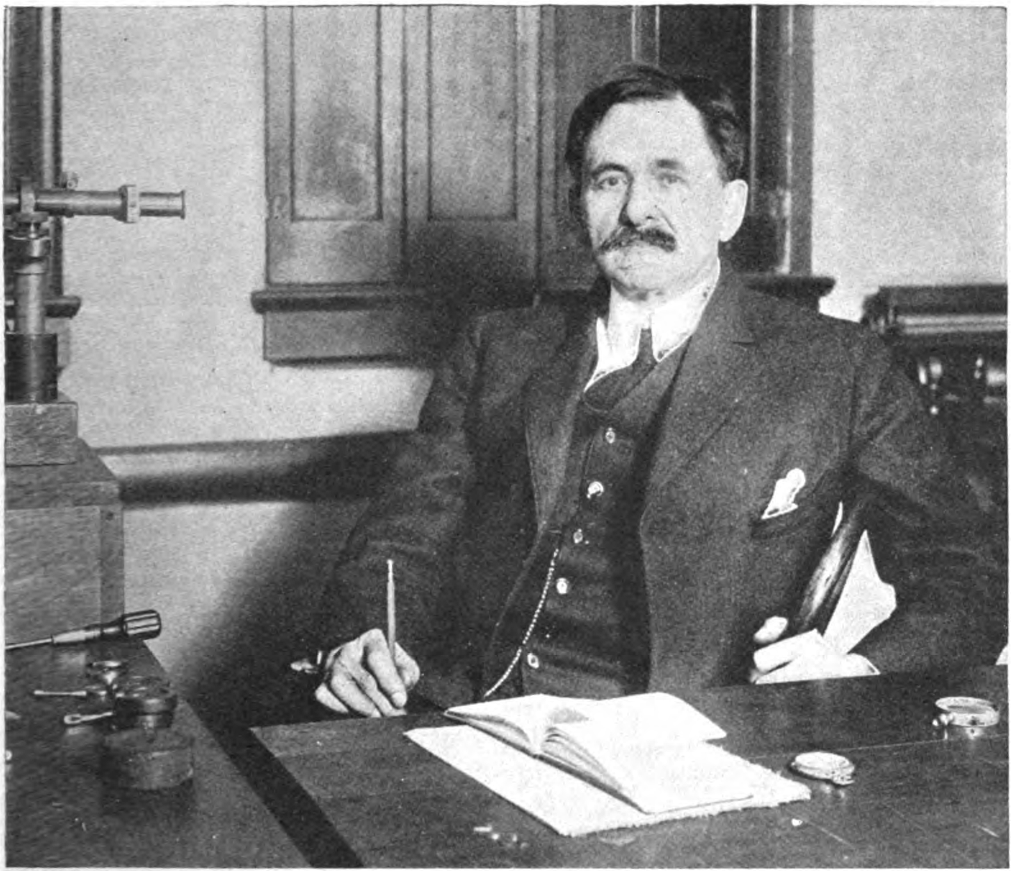


LOSSEV'S OSCILLATING CRYSTAL USED AS AN AMPLIFIER

When the voltage drop across the oscillating crystal is adjusted to exactly the right value the crystal can operate as a "negative resistance," thus causing some amplification of the signal heard in the telephones connected to the detecting crystal.

---

*The results were announced tentatively at a lecture in Chicago on January 8, 1925, this lecture being since printed in the *University Record*, University of Chicago, vol. 11, pages 136-153 (April, 1925). Details of the results are given in "The Effect of the Earth's Rotation on the Velocity of Light," by A. A. Michelson, Henry G. Gale and Fred Pearson, *Astrophysical Journal* (Chicago), vol. 61, pages 137-145 (April, 1925).



Robert H. Moulton

AMERICA'S GREATEST EXPERT ON ETHER WAVES

Professor Albert A. Michelson completed recently the most accurate measurement ever made of the speed of light. His experiment on ether-drift is described in the text. In addition, Professor Michelson has done much other important work with light rays, including the perfection of the interferometer method of measuring the sizes of the stars.

earth relative to the ether equaling approximately ten kilometers per second. More significant still, this drift varies in amount in just the way it should at different times of the day and the year, corresponding with the changing direction of motion of the particular point on the earth where the experiment was conducted.†

This leaves us confronting a sharp contradiction between two experiments which should have come out the same. It is too soon to say that the Einstein theory is disproved or even that it is notably shaken. That theory is supported in any event, by a vast amount of other evidence. But neither is it possible to say that the real existence of an ether is disapproved. If Professor Miller's results stand the tests of criticism and repetition they will furnsh strong evidence for the reality of an ether through which our earth sails along like a bullet through the air.

In the report referred to Dr. Slosson makes the interesting suggestion that the difference between the results of Professor Michelson at Chicago and those of Professor Miller at Mt. Wilson may be due to the greater altitude of the latter station. Close to the earth's surface the ether may be dragged along, he thinks, by the motion of the ground. Higher up this dragging effect may be less complete.

---

†Professor Miller's data have not yet been published in detail. They were reported orally to the National Academy of Sciences, in session at Washington, D. C., on April 28, 1925. Brief accounts by Dr. E. E. Slosson, of Science Service, appear in *Science* (Lancaster, Pa.) vol. 61, number 1584, (May 8, 1925) and number 1586 (May 15, 1925).

¶ *In* Popular Radio *for October, "How to Build the New Single Control Superheterodyne Receiver"—the latest development of J. L. McLaughlin in the* Popular Radio Laboratory.

WHAT READERS ASK

CONDUCTED BY LAURENCE M. COCKADAY

In justice to our regular subscribers a nominal fee of fifty cents per question is charged to non-subscribers to cover the cost of this service, and this sum must be inclosed with the letter of inquiry. Subscribers' inquiries should be limited to one question or one subject.

The Browning-Drake Receiver

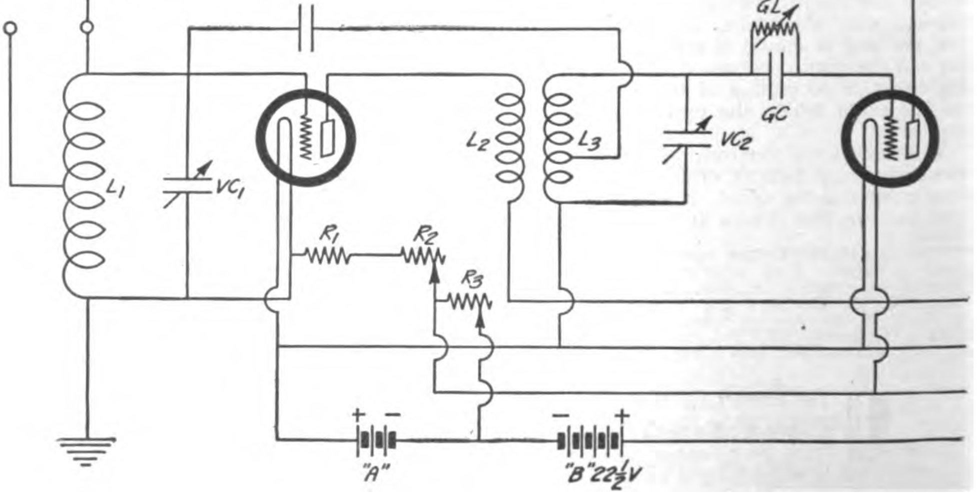
QUESTION: Will you kindly give me the proper circuit for wiring up the Browning-Drake receiver?

R. E. WILLIAMS

ANSWER: In Figure 1 you will find the circuit for this receiver. The parts you will need for this set are the following:

L1, L2, L3 and L4—inductances which comprise part of the National Regenaformer kit;
VC1 and VC2—variable condensers, .00035 mfd. and .0005 mfd. respectively which also comprise part of the above mentioned kit;
C1—mica fixed condenser, .0001 mfd.;
C2—Rathbun three-plate vernier condenser;
C3—mica fixed condenser, .001 mfd.;
C4—bypass condenser, 1 mfd.;
R1—fixed resistance, 25 ohms;
R2—filament rheostat, 20 ohms;
R3—filament rheostat, 10 ohms;
GC—grid condenser, .00025 mfd.;
GL—variable grid-leak;
J1—double-circuit jack;
J2—single-circuit jack, filament-lighting type;
AFT1 and AFT2—audio-frequency amplifying transformers.

Three standard sockets should be used for the last three tubes and one 199 type of socket for the first two. The first tube may be either a C-299 or a UV-199 tube—this is the reason for the extra resistance, R1. The three other tubes should be either UV-201-a or C-301-a tubes.



All the tuning is done with the two condensers, VC1 and VC2 while regeneration is controlled by revolving the small knob which is connected to the tickler coil, L4.

Condenser Capacity

Question: I have recently constructed a 5-tube receiver with two stages of tuned radio-frequency amplification but find that the entire broadcasting waveband lies between 5 and 60 on the dials. The tuned circuits consist of coils taken from an old neutrodyne receiver shunted by variable condensers of .0005 mfd. capacity (23 plate). The broadcasting stations come so close together on the dials, especially the lower wave stations, that it is almost impossible to separate them. I understand that this situation can be remedied either by using smaller capacity variable condensers or by removing some of the turns from the coils. Which would you advise?

Milton Glassburg

Answer: Either of the plans you suggest may be followed. However, the better plan would be to leave the coils as they are and replace the variable condensers. If you use .00035 mfd. condenser (17 plate) the broadcast band will be spread out to cover approximately from 5 to 90 degrees on your dials. Roughly speaking, you are now using only about 55 percent of the capacity of your condensers. Therefore by using condensers of lower maximum capacity you discard the unused portion of your present condensers, in this way making practically the entire dial range useful.

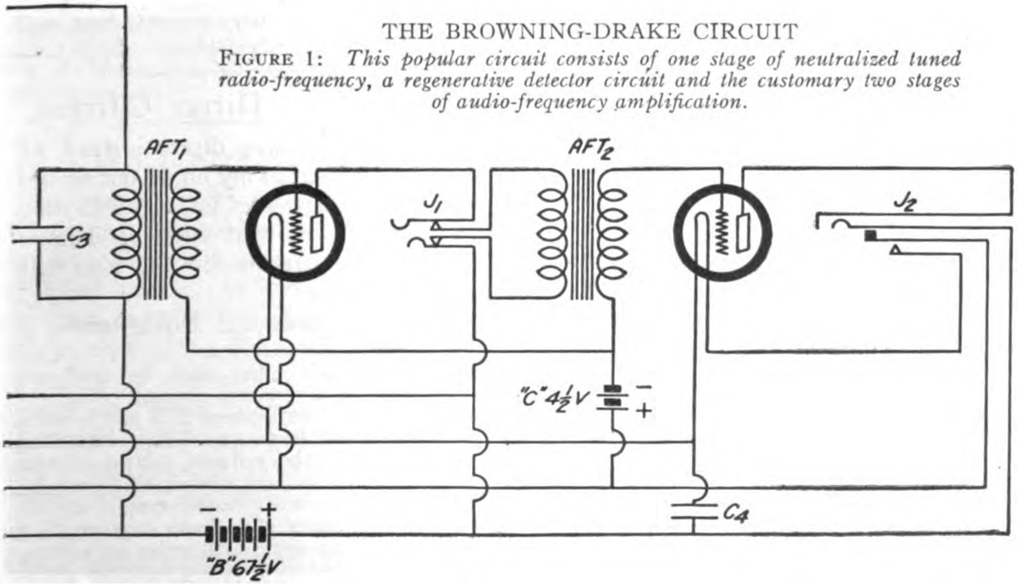
Difficulty would be encountered in removing turns from the coils because the turn ratio between the primary and secondary coils is carefully proportioned to prevent oscillation. If turns were removed from the secondary windings (which are tuned by the variable condensers) this ratio would be changed and you would find difficulty in controlling oscillation in the radio-frequency amplifier.

Voltmeter for Storage Battery Testing

Question: My storage battery is located in a cabinet and must be removed from the cabinet whenever I test it with the hydrometer. Could I install a meter on the radio set which would tell the condition of the storage battery and thus save moving the battery around?

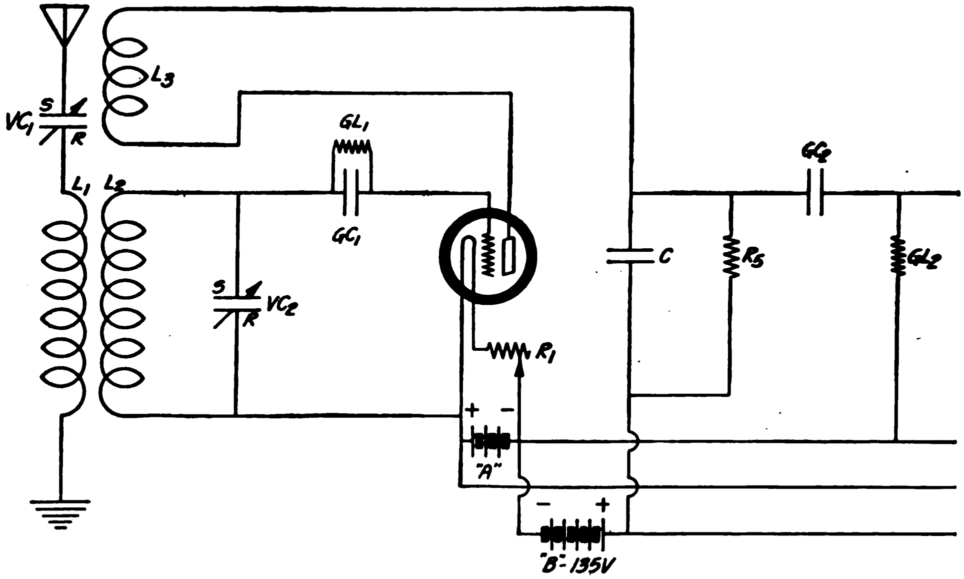
B. Montgomery

Answer: A small panel mounting voltmeter with a range of from 7 to 10 volts will give a good indication of the condition of your storage battery. The meter should be connected across the "A" battery terminals of your set and readings should be taken with the tubes in the set burning. The ordinary 6 volt acid type of battery should read about 6.6 volts when first charged and it should be recharged when the voltmeter reading falls off to 5.4 volts.



THE BROWNING-DRAKE CIRCUIT

Figure 1: *This popular circuit consists of one stage of neutralized tuned radio-frequency, a regenerative detector circuit and the customary two stages of audio-frequency amplification.*



A Novel Audio-frequency Amplifier Added to the Three-circuit Honeycomb Set

QUESTION: I want to add two stages of resistance-coupled amplification and one stage of transformer-coupled amplification to my single-tube regenerative receiver which consists of three honeycomb coils and two condensers. I want to use the transformer-coupled stage last. Will you show me how to do it?

RALPH HAHN

ANSWER: The circuit diagram for this addition to your receiver is shown in Figure 2. The coils L1, L2 and L3 comprise the triple coil set which you already have. The other parts that are necessary are given in the following list:

VC1 and VC2—variable condensers, .0005 mfd.;
C—bypass condenser, .006 mfd.;
GC2 and GC3—grid condensers, .006 mfd.;
R5, R6 and GL3—coupling resistances, ¼ megohm;
GL2—coupling resistances, ½ megohm;
GC1—grid condenser, .00025 mfd.;
GL1—grid-leak, 2 megohms;
R1, R2, R3 and R4—filament rheostats;
J—single-circuit jack;
AFT—audio-frequency amplifier transformer.

Use any make of standard hard vacuum tubes throughout. The tuning is accomplished with the two condensers, VC1 and VC2 and the coupling is varied by moving coil L1 away from coil L2. The radiation is controlled by moving coil L3 closer to or farther away from coil L2.

New McCullough AC Tube and Regeneration

QUESTION: Is the new McCullough AC tube adaptable to a regenerative circuit?

PATRICK L. NEWSAND

ANSWER: Yes; satisfactory result has been obtained with the new AC tube in various regenerative circuits. However, caution must be exercised to keep the detector tube from an oscillating condition because the moment the detector tube oscillates the AC hum will immediately become apparent.

AC Tubes on Direct Current

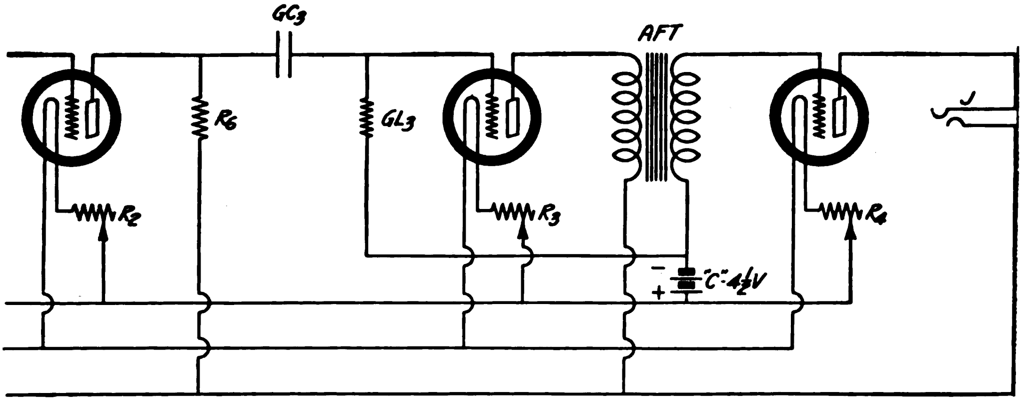
QUESTION: I have direct instead of alternating current in my house but would like to use the new McCullough AC tube instead of the usual "A" battery. I have a five-tube radio-frequency set. Can this be done?

HARRY H. NORTINGTON

ANSWER: These tubes may be used on direct as well as alternating current. The applied voltage must be between 3.25 and 4 volts for best operation, however. This means that the 110 DC must be reduced to this value. In an alternating current circuit this may be done economically with a transformer, but this device cannot be used with direct current. To reduce the voltage applied, a series resistance, capable of carrying in this case approximately five amperes, must be used. This is poor

A HONEYCOMB CIRCUIT WITH COMBINATION AMPLIFIER

FIGURE 2: *The amplifier added to this honeycomb circuit consists of two stages of resistance-coupled and one stage of transformer-coupled audio-frequency amplification. It is different in that the transformer-coupled stage is placed last.*



economy as only about 4 percent of the energy is used in the tube; the rest is dissipated in the resistance. This load will correspond roughly to that of a flatiron.

The easiest way to make a resistance is to fasten five porcelain sockets to a board and connect all of them in parallel. One wire, connecting all the terminals on one side, should go to the plug and another wire connecting the remaining terminals on the other side should go to the "A" battery terminal on the set. The second plug terminal should go to the other "A" battery post. (For details of the connections for the filaments see page 511 of the June 1925 issue.) Four 100-watt lamps (or a combination giving the equivalent) should be inserted in the first four sockets. Lamps varying from 25 to 100 watts should be inserted in the last to get the proper resistance. Use the lowest possible wattage consistent with good reception.

What Size Rheostat?

QUESTION: With rheostats of so many different resistances on the market, how am I to determine which to use with the different tubes? In one receiver I constructed recently I used a 20-ohm rheostat to control the filaments of five 201-a tubes, as I understood this to be the proper resistance to use with this type of tube. However, upon putting the set into operation the rheostat became very hot and in a short time burned out. Why was this, and what type of rheostat should I have used in this case?

HERMAN SCHWENK

ANSWER: A 20-ohm rheostat is suitable for a single 201-a tube or even for two such tubes. However, when several tube filaments are operated in parallel through one rheostat the current passing through the rheostat is the sum of the current requirements of the several tubes. In the case of five 201-a tubes the total current drain is about 1¼ amperes and the average 20 ohm rheostat has a current carrying capacity of only ½ ampere. It is therefore evident that the rheostat was heavily overloaded in the case you mention.

Following are the rheostat resistances required for various types of tubes:

1—201-a tube, 20 ohms;
2—201-a tubes in parallel, 20 ohms;
3 or 4—201-a tubes in parallel, 6 ohms;
5 to 8—201-a tubes in parallel, 2 ohms;
1—UV-200 tube, 6 ohms;
1—199 tube, 50 ohms;
2—199 tubes in parallel, 30 ohms;
3 to 5—199 tubes in parallel, 20 ohms;
6 to 8—199 tubes in parallel, 6 ohms.

When two or more tubes are used in parallel and operate through a single rheostat less resistance is required than when only a single tube is drawing through the rheostat. Fortunately, it is also true that the lower resistance rheostats have a greater current carrying capacity than those of higher resistance. Therefore, the low resistance rheostats are suitable for several tubes in parallel, not only in resistance but also in their current carrying capacity.

The Oscillating Receiver

QUESTION: At irregular intervals my receiving set squeals to such an extent that reception is almost entirely blotted out. These noises, I have been told, are caused by other receiving sets in my vicinity. I would like to know if there is any attachment which could be applied to my set that would filter out these squeals?

A. B. Clayton

Answer: There is no such device for eliminating the squeals caused by your neighbors. Each operator of a receiving set should see that his own set never oscillates as he owes that much to the general radio public. The scheme for elimination of oscillation is to tune in the signal first and then increase regeneration to strengthen the signal.

One Stage Neutralized Radio-frequency, Crystal Detector and One Stage of Audio

Question: I have a single-tube receiver which is regenerative that employs a variometer with a fixed condenser in the antenna circuit. I would like to add one stage of radio to this receiver, a crystal detector and one stage of audio, so that it will operate a loudspeaker. The one stage of radio I would like to have neutralized like in a neutrodyne.

T. F. Baer

Answer: In Figure 3 we have drawn a hook-up for the final design of your receiver. The parts you will need in rebuilding this set, including the ones you already have, are the following:

VAR—variometer;
RFT—neutrodyne coupling unit;
C1—mica fixed condenser, .00015 mfd.;
C2—neutradon condenser;
R1 and R2—filament rheostats, 20 ohms;
J—single-circuit jack;
DET—crystal detector;
AFT—audio-frequency amplifying transformer.

All the tuning of this receiver is done with the variometer, VAR. The neutradon condenser, C2, should be adjusted by placing a small piece of paper over one of the filament terminals of the first tube and inserting it in the socket so that it will not light. Then, the condenser, C2, is adjusted until the signals are reduced to as low a value as possible. When this is done the receiver is neutralized and the first tube cannot oscillate or cause radiation. The crystal detector will have to be adjusted for suitable sensitivity before this can be done, however.

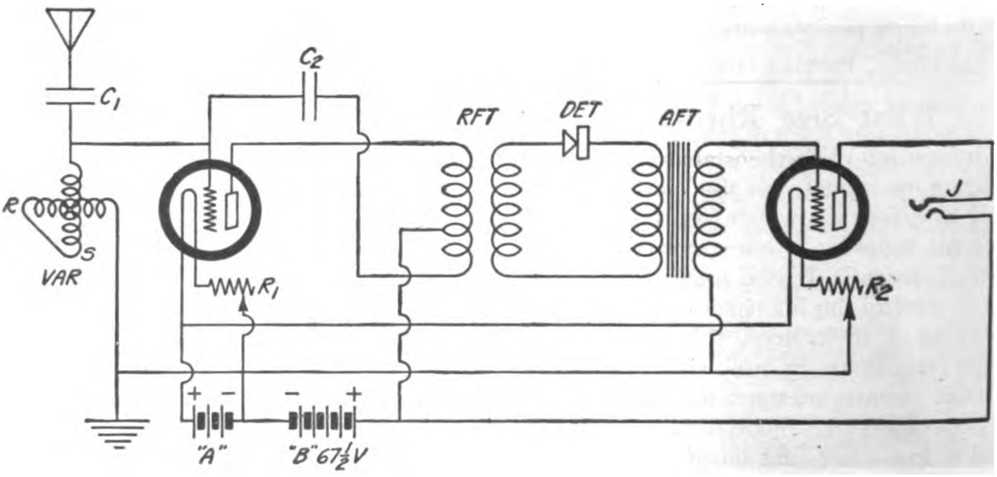
Use two C-301-a or UV-201-a or any other standard make of ¼ ampere hard tube for this set.

How to Eliminate Microphonic Noises

Question: To what are microphonic noises due and how can they be eliminated?

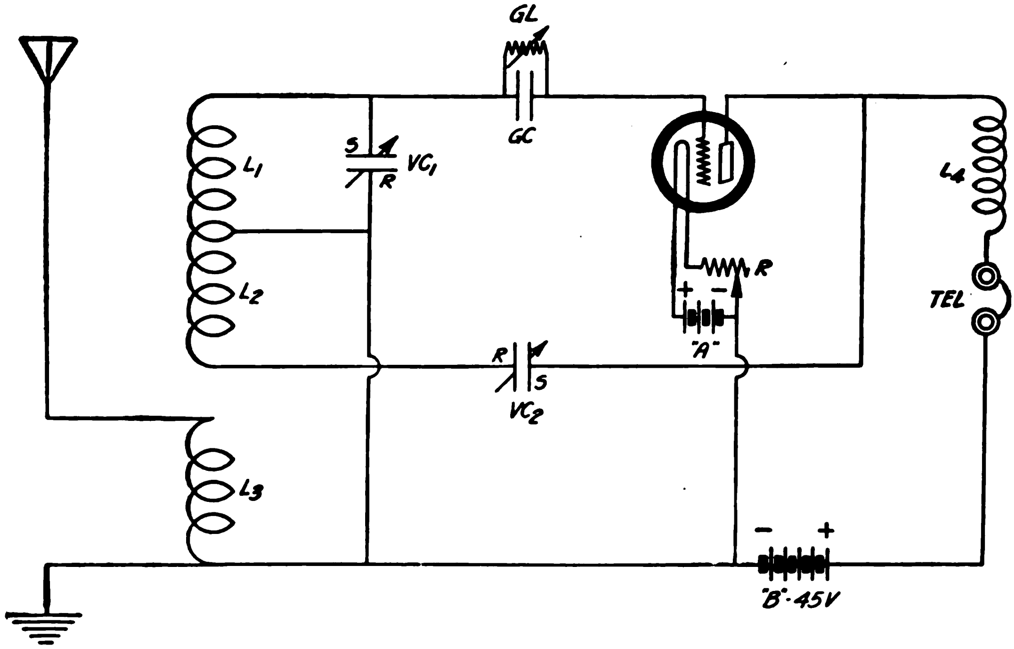
John Gillies

Answer: Microphonic noises are sometimes due to vibrating elements in a tube. This condition is sometimes overcome by putting in a non-microphonic cushion socket, or by putting rubber cushions under the four corners of the receiver.



A SENSITIVE TWO-TUBE CIRCUIT

Figure 3: *This diagram shows how to change a single tube regenerative circuit over to a non-radiating set. The stage of audio-frequency amplification requires one additional tube.*



A CIRCUIT FOR THE SHORT WAVES

FIGURE 4: *The single tube circuit in this diagram is satisfactory for the experimenter who is bent upon receiving the short-wave C.W. stations. The number of such stations is steadily increasing.*

A Novel Short-wave Regenerative Receiver

QUESTION: Please give me a diagram showing a form of short-wave receiver that employs a condenser for controlling regeneration. I want to use this receiver for C.W. signals.

LAURENCE TAIT

ANSWER: In Figure 4 you will find a circuit diagram for a regenerative receiver employing one tube. The parts you will need for this set are the following:

L1 and L2—single-layer solenoid coils tapped in the center;
L3—single-layer solenoid coil;
L4—single-layer solenoid coil;
VC1 and VC2—variable condensers, .00025 mfd.;
GC—grid condenser, .00025 mfd.;
GL—variable grid-leak;
R—rheostat, 20 ohms;
TEL—telephones.

Coils L1, L2 and L3 are wound with about No. 22 wire spaced the thickness of one wire on a tube 3½ inches in diameter. Coil L1 consists of 10 turns of wire; L2 consists of 6 turns of wire; L3 consists of 4 turns of wire and L4 consists of 150 turns of wire wound on a one inch tube.

All the tuning is done with VC1 as far as wavelength is concerned and regeneration is controlled with condenser VC2. Coils L1, L2 and L3 may be experimented with for increasing or decreasing the wavelength range of this type of receiver.

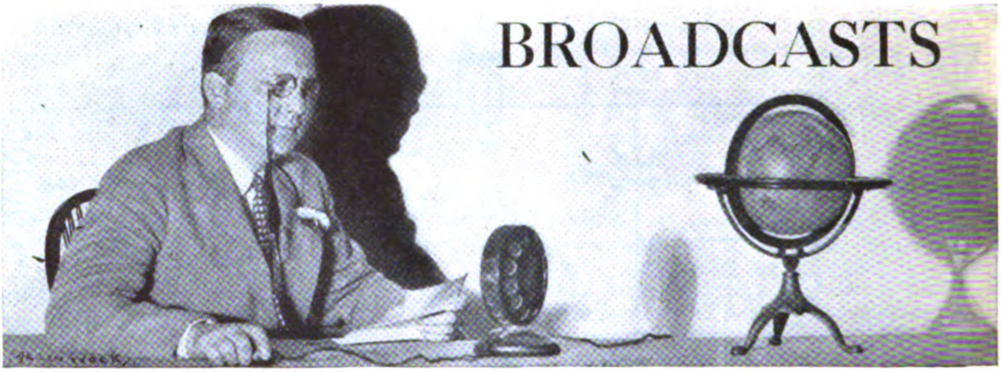
The Principle of Modulation

QUESTION: What is meant by "modulation?" I have often heard the word but it seems never to be explained in a popular way.

A. ANIERO

ANSWER: When the announcer talks into the microphone the carbon granules which compose part of the microphone vibrate in accordance with the voice frequency. This vibration in turn varies the resistance of the circuit of the microphone and causes rapid changes in the amplitude of the carrier-wave current. This variation then comes into our receiving set as the announcer's voice. The change of amplitude that takes place in the carrier wave is called "modulation."

BROADCASTS



CONDUCTED BY J. ANDREW WHITE

IN *this department the Dean of Broadcasters—whose voice is known to millions of broadcast listeners—records items of interest and value to all radio fans everywhere.*

Stopping Bad Radio Manners by Injunction

KEEP it clean has been the one thing broadcast station directors have been very particular about from the beginning. It is gratifying to see how ably the courts supported this policy in reviewing one of the first and one of the most important slips, a series of so-called "health talks" which waved themselves off the antenna of WFBH on the roof of the Hotel Majestic, in New York. An injunction was granted the hotel people to "pull the switch" on programs which do not measure up to the reputation of refinement the hotel enjoys. The case developed, incidentally, that the health talker had been convicted ten years ago on a charge of maintaining a nuisance, which seems to remove any chance of an alibi on the part of the radio concern which leased the space. Personally, I am not familiar with any previous dereliction of duty as flagrant as this; it is customary to require manuscript copies of talks in advance; and this is as it should be.

* * *

Yes, but Who Wants to Listen in on Lawmakers?

WHEN the question of broadcasting the proceedings of both houses of Parliament came up in England recently, the Prime Minister advised setting up a committee to report on the matter. Whereupon spokesmen for the British public at large facetiously suggested a plebecite to determine whether listeners themselves favored an additional burden of tedious political speeches. Which is somewhat like our own situation; the supply of oratory in the halls of Congress seems still to be far in excess of the demand for its propagation.

* * *

A Radio Net Spreads Over Soviet Russia

THE Soviet is figuring on erecting nine new radio stations to enable the distant Siberian peasant to get advice on his farming problems direct from the agricultural colleges in European Russia. The latest inventory discloses the fact that there are forty-three transmitters and 282 receivers scattered throughout the territory of the Soviet Union; fifty new receiving stations are to be built. Incidentally, sets and parts manufacture has been turned over to a State syndicate.

* * *

How to Check Up on Wavelengths

IF it interests you to scratch on your dials the place where definite wavelengths are to be heard, rather than work with a station log and arbitrary numerals, you may listen in twice a month to radio signals of definitely announced frequencies transmitted by the Bureau of Standards from Washington and California. All the dope on how to receive and utilize this service is given in Bureau of Standards Letter Circular No. 92. It's free. Write to the Bureau of Standards, Washington, D. C.

* * *

"Radio Sport" as Played by Fritzie

THEY call broadcasting "radio sport" in Germany, which in itself is just about as interesting as the fact that in two years as many subscribers have been gained for the ether-wave variety as have lined up for the Government's wire telephone in forty years. Radioing started out as a state monopoly, but the advocates of unrestricted development whose main argument was the growth of radio in the United States, did succeed in getting across a compromise and all wavelengths up to 800 meters are released by permit to broadcasting companies. But the Government holds majority control and title to the apparatus. There are now nine of these companies operating the same number of stations; also a total of five sub-stations, with three more to come. Every listener must have a post office permit, which costs two marks a month, local postmen taking care of the collections from the 714,352 registered subscribers. The latest move is to hop up the power from 1,500 watts to 8,000 and 10,000 watts and inject more variety in programs which have had a preponderance of intellectual and educational features.

* * *

A New Record in Sales of Radio Apparatus

Eight million dollars is the estimated total value of America's exports of radio apparatus when the year shall have come to an end. Very close to half that amount was shipped abroad in the first five months of the year, the total for the period and the monthly average showing respective increases of 123 percent and 130 percent, on which basis all existing records should be broken.

* * *

Radio Waves 2,200 Feet Below the Earth

Any question remaining that radio waves penetrate to great depths into the earth seems to be pretty well answered by the success of Meade W. Powel, an amateur of Warren, Ariz., in picking up a distant naval station while 2,200 feet below the earth's surface. He had no success with bare copper wire nor with a loop, but when he tried 100 feet of lead-covered No. 14 copper wire cable strung along the mine gallery midway between the roof and the floor, NPL, 400 miles distant, came in on a three-tube regenerative outfit, although a five-tube radio frequency set wouldn't percolate at all. Maybe it was freak reception, but the experiment is interesting because no means has yet been devised for two-way communication of a continuous order in the interest of saving lives and keeping in touch with entombed miners when a disaster takes place. The main problem, of course, is to overcome the rapid deterioration due to dampness, which breaks down insulation.

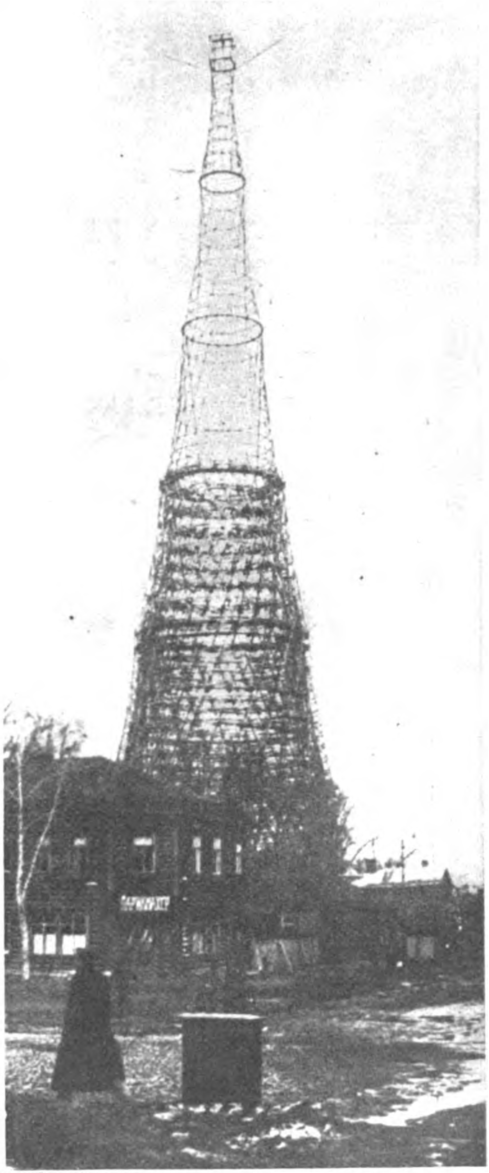
* * *

The Broadcasting Stations of the World

Everybody knows that the United States leads in the number of stations transmitting news and entertainment, in fact that we have more stations than all the other forty-one countries added together, and there are those who think that this is not an unmixed blessing. But it is surprising to learn that Canada holds second place with eighty-three stations; then Russia, with forty-three; and Cuba fourth with thirty-eight stations. Great Britain and Mexico are tied for fifth place with twenty each. France and Germany, eighteen apiece, share sixth place. Then comes Australia with sixteen, and Argentina with thirteen. From this figure downward the numbers decrease rapidly, six small nations bringing up the rear, each with a single broadcaster.

Linking the Telephone to Radio

In Hawaii they are planning to use a radio system between several central exchanges of a local telephone company. Central will be called in the usual way from any phone, and if the call is for one of the other islands the voice



Pacific & Atlantic

WHERE THE "RED PROPAGANDA" COMES FROM

The famous antenna tower of Shablovka at Moscow, which the Soviet Government of Russia has made the center of its broadcasting activities.

will hop across the water on a wavelength between 66 and 70 meters and be connected up at the other end with the phone of the subscriber in the usual manner. Experimentally, this has been done often; there doesn't seem to be any reason why such communication cannot be maintained commercially. We will find out, anyhow, because they are alive in Honolulu; I recall that one of the earliest of the automatic calling disc telephones there worked itself out to familiar practicality.

* * *

What the Broadcasting of Advertising is Doing to One Station

In the city of Durban in South Africa the listeners won't stand for advertisements mixed up in the programs. They went on strike recently when advertising appeared along with the entertainment and made known their wishes very effectively by refusing to pay the license fee which is required of set owners. Initially, the audience was 500 persons; now there are only 200 licensees, and it looks as if the station will have to run at a heavy loss. In an effort to recoup, the directors of the station agreed to leave off mentioning advertisers on the air but to publish them in official programs, distribution of which immediately went into a slump. The scheme was then tried of selling programs only to those who gave their full name and address on special blanks. This idea was successful only in increasing the ire of the listeners, and at last reports the sale of programs had fallen almost to zero.

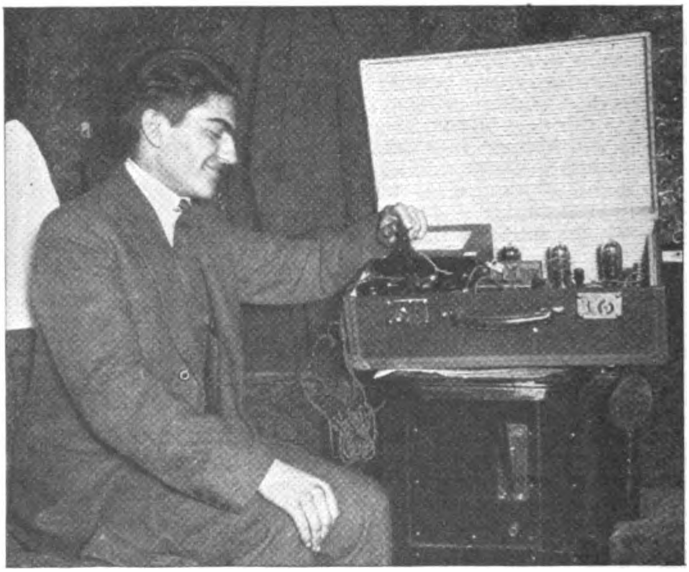
What the Austrian Fan Likes Best

Those straw vote things, as to listeners' program preferences, of which we have had a plentiful sufficiency, have now invaded Austria where broadcasting is a tender infant not yet a full year in existence. The publication which conducted the feature required the first three choices to indicate positive interest. And the Viennese picked them in this order: concerts, time signals and financial talks! Education nosed out humor, operas beat out plays, daily news was preferred to dance music—a lot of things cropped up that seemed hard to reconcile with America's radio sophistication, notably that the tailenders included sports and sermons. But there are some 50,000 receiving sets in the country under a license system with the individual paying a fee of from 15,000 to 30,000 crowns a year for the privilege of tuning-in, so the Austrians must like what they have been getting since last October.

* * *

What Will the Author and Composer Make Out of Radio?

Atlantic City saw the first annual convention of the Radio Manufacturers Association recently and a major topic of discussion was the adjustment of differences which have arisen between station owners and the American Society of Composers, Authors and Publishers; a committee was apopinted with a view toward reconciliation of these differences. Although little known to the public, this clash of inter-



F. M. Delano

RADIO RECEPTION AT A MILE A MINUTE

J. L. Menars, the well-known French amateur, recently experimented with this portable set on a French sleeping car, hooking it up to the train lighting system and using the heating pipe as a ground. He picked up stations in England, France, Spain, Germany and Wales, while traveling 60 miles an hour.

Pacific & Atlantic

SOUND WAVES THAT ARE HEARD BY THE HANDS

Unique experiments are being made by Dr. Robert H. Gault, professor of psychology at Northwestern University, in conveying language to the deaf by means of telephone receivers that are held in the palms of the hands; the vibrations enable the subjects to "hear" words spoken into the transmitter.

ests, which has been active for several years, presents one of the most absorbing problems in broadcasting ethics with which the industry has been confronted. The station owners are practically united in agreeing that suitable reward and compensation is due the men who write the nation's songs; but they can't see the point of accepting license contracts which run for one year only and leaving the future wide open for charging whatever fee the traffic will bear. Already, the Society is guilty of charging one station a certain price and insisting that, for the same privileges, another station pay a great deal higher royalty figure. The figure seems to vary from $250 a year to ten times that amount, and the most recent demands run even higher. So far as I know, no broadcasting station in the country is making money today; how many will continue in existence under an additional financial burden, the size of which cannot even be anticipated, is a pretty question. It is a question that rightfully belongs to the public, the listeners, whose entertainment must predominate in the forthcoming attempt to place the interest of the broadcasters and the music publishers on a working basis.

* * *

Broadcast Programs on a Wire Spool

Somewhat closer at hand is the day—or perhaps better, the night—when the radio fan will be able to hear programs broadcast while he is asleep. And hear them as often as he wants, repeated by what, in Germany, is known as the talking wire. The idea is, that you set the recording instrument, attached to the radio receiver, and speech, music, and all other sounds are permanently retained on thin steel wire running between two spools, tonal differentiations being registered through the reactions of a small electromagnet. Eighteen years of laboratory research are said to be behind the achievement of this apparatus, which is accredited to Dr. Kurt Stille, but from the incomplete advance reports it looks as if the device is merely a modification of the machine invented some years ago by Waldemar Poulsen, a Danish scientist, who produced an electromagnetic recorder that was simplicity itself and certainly worked well, but struck the snag of too high cost when an attempt was made to introduce it commercially. If the price is right this time, the market is wide enough. Yes, I want one, too!

* * *

The Don Is Stirred by Radio Waves

While Spanish playwrights and composers have been seeking relief from unauthorized broadcasting of their works, public interest in radio throughout Spain has been stirred up by the addition of two stations in Balboa, duplicating the situation in the vicinity of Madrid, where another pair serves. Power three times as great as the earlier ones, incidentally, has been provided for the station just completed at Seville.

* * *

The Irish Still Squabbling Over Their One Proposed Station

THE Irish haven't gotten around to it yet. Over a year ago the Dail disposed of legal difficulties and called for plans for a broadcasting station that would be the Free State's very own. The optimists who bought their sets a year ago are becoming a bit fretful, but the Dail has not acted on the plan nor considered it in any way.

* * *

Locating Air Vessels by Radio Compass

WHETHER or not the radio compass is of value to airships while aloft is the latest problem the Navy has undertaken to solve. The dirigible *Shenandoah,* engaged in a game of hide and seek with the battleship *Texas,* is the interesting form given to the test. The ship being given 100 miles start at sea upon a course unknown to the airmen, the only means of spotting the vessel will be the radio compass employed while the *Texas* is using its radio apparatus. In like fashion, when the *Shenandoah* transmits, it will enable the *Texas* to locate the big balloon and steer clear.

* * *

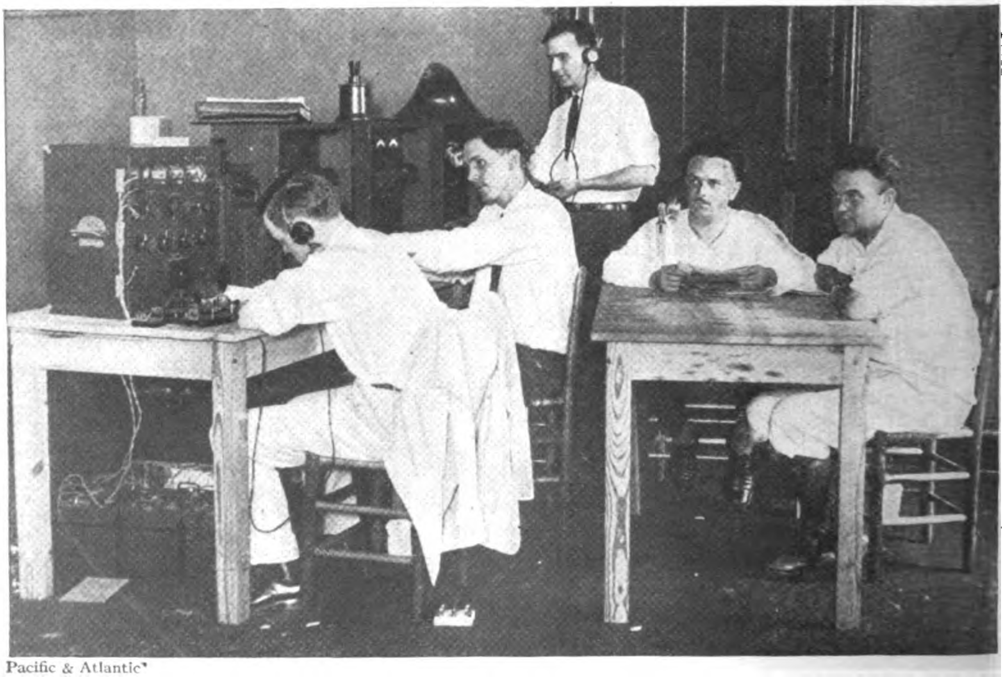
What Programs Do the Farmers Want?

THE farmer is to get what he wants in the way of programs. Questionnaires are to be placed in the hands of 850,000 tillers of the soil as part of the program for conducting a survey by the National Farm Radio Council in co-operation with thirty farm magazines. Previous radio surveys have confined themselves to determination of the number and nature of the receiving sets in the rural sections; this one will deal exclusively with preferences in program material.

* * *

One Public Service Engineer Kills "Anticipated Static"

COMPLAINTS by residents of Orange, N. J., that "artificial static" was mutilating broadcast programs to the point of distorted whisperings, resulted in the declaration by the chief engineer of the municipal lighting plant that radio is no longer a novelty but a necessity, and forthwith an order was given for installation of choke coils to overcome the annoyance caused by arcing brushes.



Pacific & Atlantic

RADIO PLAYS A PART IN THE "EVOLUTION TRIAL" IN TENNESSEE

For the first time in the history of American jurisprudence, the proceedings of a criminal trial were broadcast from a courtroom when John T. Scopes, a teacher of Dayton, was prosecuted for teaching scientific theories of evolution. Station WGN of Chicago broadcast the event.

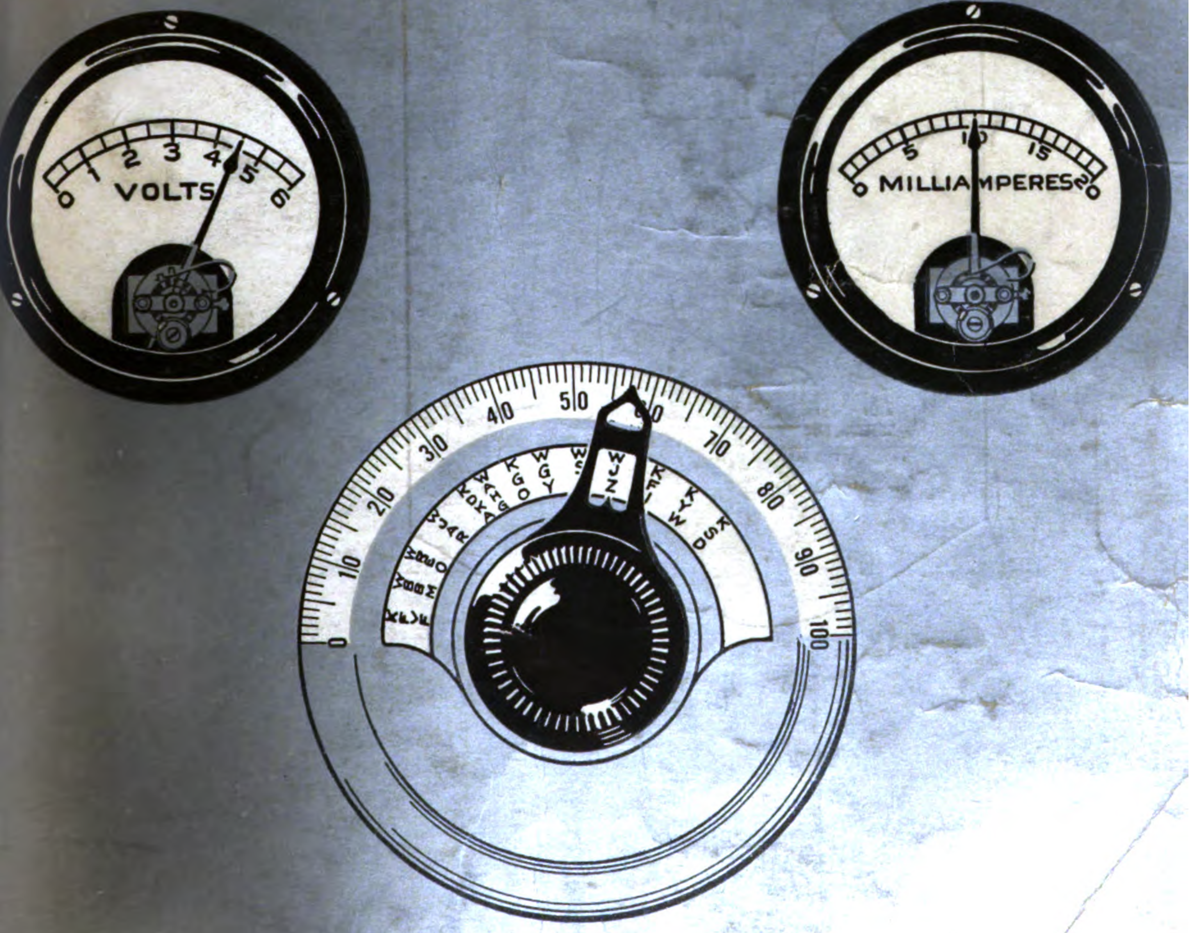
Popular Radio

with which is combined The Wireless Age

Edited by KENDALL BANNING

25¢

OCTOBER · 1925



How to Build the New SINGLE CONTROL Superheterodyne Receiver

CHOSEN
by
VICTOR
and
BRUNSWICK

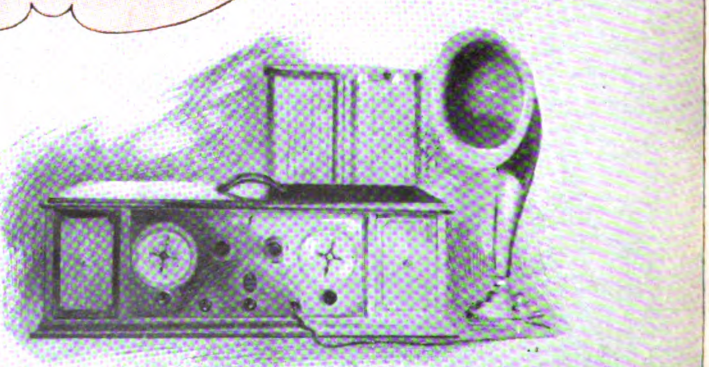
RCA **Radiola**
REG. U.S. PAT. OFF.
AN RCA PRODUCT

Two great manufacturers—working independently and competitively—set out to find the radio receiver worthy to be combined with phonographs that have a world-wide fame to uphold.

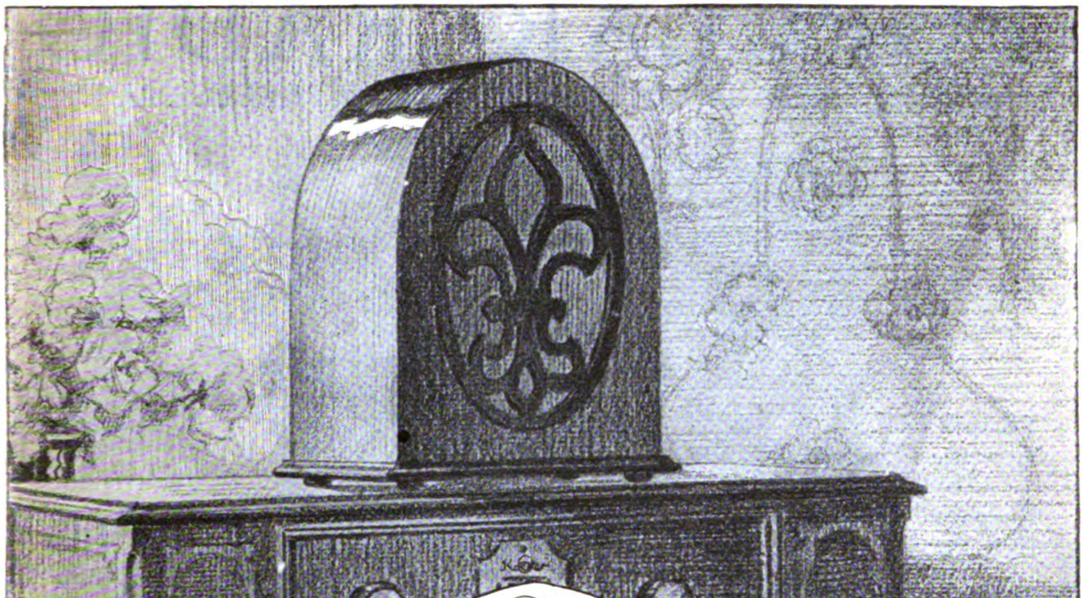
They had every known kind and variety of radio set to choose from. They had every facility for research, test and exhaustive study. And they had a firm determination to combine with the Brunswick phonograph and the Victrola only that radio set which proved to be the leader today and which carried full promise of holding that leadership through the years of tomorrow.

Both chose the Radiola.

Radiola Super-Heterodyne, the most famous of Radiolas. With the new power Radiotron as its sixth tube, it achieves new volume of tone and finer tone quality than ever.



RADIO CORPORATION OF AMERICA CHICAGO NEW YORK · SAN FRANCISCO



The Brandes Cone—a truly decorative bit of furniture that conceals a remarkable speaker. $38

Low tones high tones —all clear, round, real

The Type H—graceful lines, antique green and black finish. Adjustable. . . $18

The Brandes Cabinet of mahogany in walnut finish. Same unit as Type H Speaker. $30

The Adjustable *Table-Talker*. Gooseneck horn for clearer, rounded tone. Finished in brown. Adjustable. . $10

The Phonograph Attachment. Adjustable, will fit all phonographs $10

JUST listen! Very low tones—the kind that used to be muffled and lost. Here they are—true and clear. A high soprano that used to be a bit thin in the upper register. Here it is, perfectly rounded—and real!

And this rare tone quality is characteristic of all Brandes products. The new Cone Speaker, the Cabinet Speaker, the Horn—Type H. Even the phonograph attachment—which gives true Brandes tone through any good phonograph horn. They're all worth hearing!

All prices slightly more, west of the Rockies and Canada.

Send for an interesting booklet describing Acoustics by Brandes.

Brandes Products Corporation
200 Mt. Pleasant Ave. Newark, N. J.

© Copyright by Brandes Products Corp. 1925

Brandes

EXPERTS IN RADIO ACOUSTICS SINCE 1908

POPULAR RADIO

WITH WHICH IS COMBINED "THE WIRELESS AGE"

EDITED *by* KENDALL BANNING

FOUNDED 1911

CONTENTS *for* OCTOBER, 1925

(*Cover design by Frank B. Masters*)

VOLUME VIII NUMBER 4

How the Powers Have Built a Radio Wall Around China . . . . . FRONTISPIECE

Radio and the War Menace . . . . . *Bruce Bliven* . . . . . *Page* 301

How Earth Magnetism Affects Radio Waves . . . . . *H. W. Nichols and J. C. Schelleng* 309

Handy Tools for Radio Fans 317
No. 7: The Electric Soldering Iron

How to Improve Broadcast Reception . . . . . *John V. L. Hogan* 318
No. 7: How to Reduce Interference

Men Who Made Radio 324
10th Installment

What Makes a Low-loss Coil? . . . . . *Charles T. Burke* 326

Simple "How-to-build" Articles for Beginners . . . . . *Laurence M. Cockaday* . . 330
No. 12: How to Build an Inductively-coupled Wavetrap

Secrets of the Studio . . . . . *Paul Godley* 334

How to Compare Losses in Condensers . . . . . *Sylvan Harris* 340

"What Set Shall I Buy?" 346

How to Build the New Superheterodyne with a Single Control . . . . . *James L. McLaughlin* . . . 350

DEPARTMENTS

What Readers Ask . . . . . *H. S. Knowles* 364

The Broadcast Listener . . . . . *Raymond Francis Yates* . . 370

What's New in Radio Apparatus . . . . . *The Technical Staff* 374

In the World's Laboratories . . . . . *E. E. Free* 378

In the Experimenter's Laboratory . . . . . *Laurence M. Cockaday* . . . 386

Broadcasts . . . . . *J. Andrew White* 391

VOLUME VIII OCTOBER, 1925 NUMBER 4

Published monthly by Popular Radio, Inc., 627 West 43rd St., New York, N. Y., telephone number, Chickering 1906; Douglas H. Cooke, President and Treasurer; Kendall Banning, Vice-President; Laurence M. Cockaday, Secretary; Joseph T. Cooney, Asst. Treasurer. Price 25 cents a copy; subscription $3.00 a year in the U. S., Canada and all countries within the domestic postal zone; elsewhere $3.50 a year, payable in advance. The International News Company, Ltd., No. 5 Bream's Bldg., London, E. C. 4, sole distributors in England. Entered as second class matter April 7, 1922, at the Post Office at New York, N. Y., under the act of March 3, 1879.

Copyright, 1925, and title registered as a trade-mark by Popular Radio, Inc. Copyright in Great Britain by Popular Radio, Inc. 6 Henrietta St., Covent Garden, W. C., London, England.

Printed in U. S. A.

LAURENCE M. COCKADAY, *Technical Editor*

E. E. FREE, Ph.D., *Contributing Editor* JOHN V. L. HOGAN, *Contributing Editor*

For advertising rates address

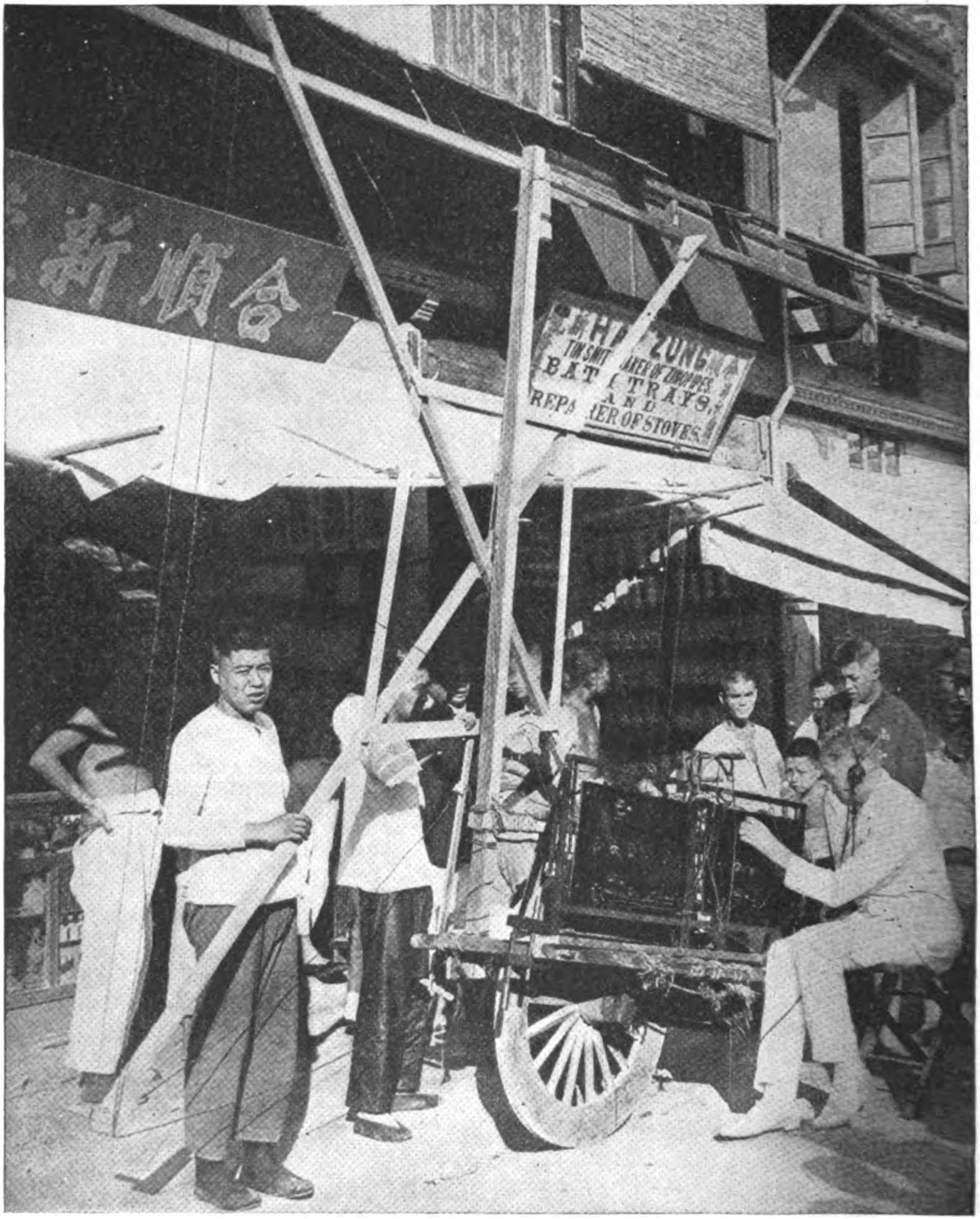
E. R. CROWE & COMPANY, INC.

New York: 25 Vanderbilt Avenue Chicago: 225 North Michigan Avenue

Popular Radio Points the Way

"Popular Radio *has done more than any other medium to point out to those of us who are vitally interested in both the scientific and the commercial aspects of radio what the future holds; between its covers I have found time and time again the most extraordinarily accurate forecasts of future public interest.* Popular Radio *makes the work of all of us easier.*

PRESIDENT, HAYNES-GRIFFIN
RADIO SERVICE, INC.



Underwood & Underwood

How the Western Powers Have Built a Radio Wall Around China

ONE *of the chief grievances of China at the present time is that she is not permitted to own or operate a radio station of her own; therefore the outside world can get no news about China, which has not gone through the censorship of the powers that control radio in that country. Even her local broadcasting is done mainly from foreign-owned stations.*

Popular Radio

WITH WHICH IS COMBINED "THE WIRELESS AGE"

VOLUME VIII OCTOBER, 1925 NUMBER 4

Radio and the War Menace

"One of two things is certain: Either radio will become one of the most powerful agencies for peace the world has yet seen—or it will be one of the most potent causes of war in all history."

By BRUCE BLIVEN

A FRIEND of mine, an intellectual person who might fairly be described as a professional highbrow, said to me the other day:

"Why are you interested in radio? It is only a sort of substitute for a phonograph. It will certainly never amount to anything which any serious person need take seriously."

I didn't answer my friend; the day was too hot to argue. But I thought to myself that back in 1450 any of the good citizens of Strassburg might have said to Burgher Fust, who was then all excited about an invention in which he had been investing, an invention of one Johann Gutenberg:

"Why do you bother with this so-called printing press? It is only a clumsy substitute for manuscript. Mark my words, it will never amount to anything."

I

RADIO stands today about where printing stood in 1450, when it was twelve years old. In my judgment the history of the one is a fair basis from which to predict the history of the other. I need hardly say to my present readers that the changes in human affairs brought about in the past by the printing press are likely to be paralleled in the future as a result of harnessing the ether. Remarkable as has been the improvement in the mechanics of printing since Gutenberg's day, all such progress is as nothing compared to the social development he made possible. Radio, too, regardless of its technical advance, is destined to make a new world. Of its multifarious effects, none will be more important than its bearing for good or for ill upon the relationships among the nations.

Everyone who thinks at all realizes that nowadays the prevention of war has become just about the most pressing problem on earth. In former times such a conflict was a mere incident in the life of the nations involved; today, a struggle between any two important powers requires all their resources of men, machines and money. Moreover, we know from recent and vivid experience that war between any two great powers is likely to draw in others until nearly the whole world may be involved. We know, furthermore, that such a struggle if prolonged is disastrous to all the participants, financially, economically and even spiritually, whether they win or lose. Plenty of hard-headed, conservative men, who are in a position to know, will tell you that if the European war had gone on much longer it would have meant the complete overthrow of that intangible but precious thing which we are pleased to call "Western civilization."

Twenty or thirty years ago, the effort to prevent war and seek alternative methods for settling international disputes was a matter which interested for the most part only a few elderly and rather fuzzy-minded clergymen and ladies.

Today it is a question of major concern for the whole world, to which the leading statesmen of the chief powers devote their best efforts.

Radio is certain, then, to play a most important role in the future relations among states. I should like to be able to assert, with offhand cocksureness, whether its influence will be for good or evil; but as I shall try to prove in a moment, it is impossible to be dogmatic about it. One of two things is certain:

1. Either it will become one of the most powerful agencies for peace the world has yet seen—

2. Or else it will produce such serious international discord that it may prove one of the most potent causes of war in all history.

II

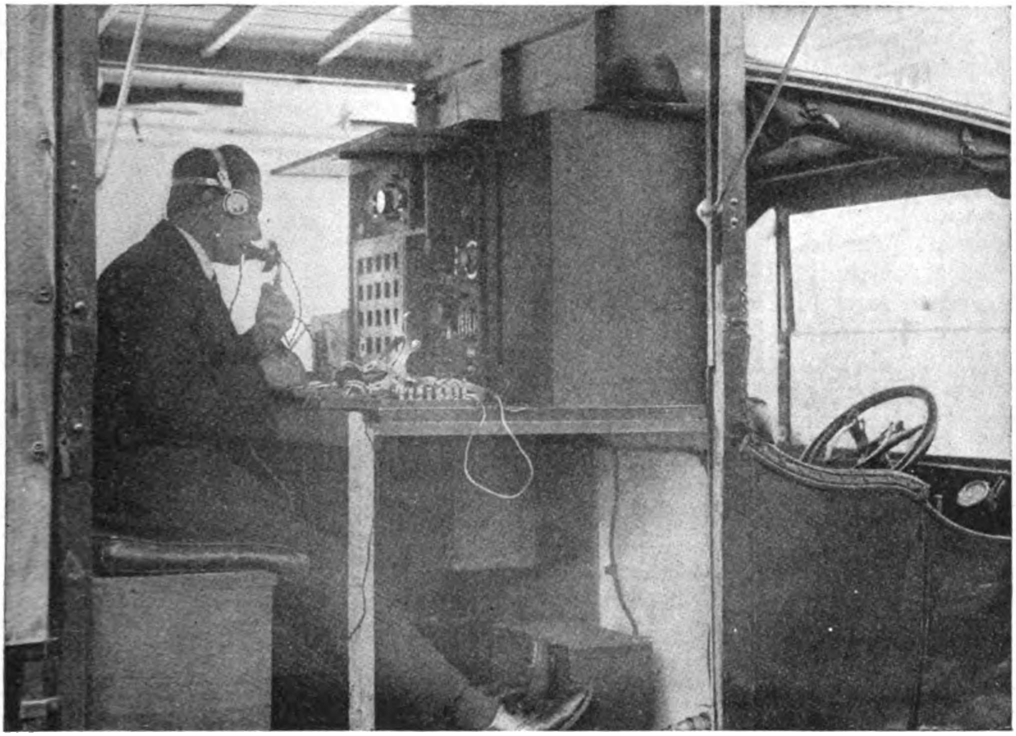
EVERYONE knows that broadcast reception is already possible on such a scale that it crosses international frontiers. I am not thinking now of the few experiments conducted with special apparatus plus great skill and patience, in which ethereal messages have been sent successfully halfway 'round the world, but of ordinary average reception on an ordinary average good receiving set.

If the capital of every important nation were the scene of high-powered broadcasting, already there is hardly a spot in any thickly-populated country today which is so remote that it could not get good reception, under favorable weather conditions, from at least two of these stations.

In Europe, which is one of the chief powder magazines of the world at present, so far as war is concerned, this is even more strikingly true.

Broadcasting from any European country can be received in practically every other. Everything put on the air in France, Italy, Germany, for instance, is heard in at least six or eight countries and by people speaking that many tongues, if not more.

That fact is itself beginning to produce results which are destined to be of great importance so far as international peace and understanding are concerned. Nobody wants to listen to broadcast reception in a language which he doesn't understand. Also, radio unfailingly and everywhere creates "DX hounds;" few are long satisfied merely to get local stations which use the speech of their fathers. Accordingly, although radio broadcasting in Europe is much less advanced than it is in America, there is already a good deal of pressure to have all or most of the broadcasting done in one language. Present indications are that English is likely to be selected for this. Its only possible competitor, of course, is French, which has for centuries been the common language of international diplomacy. However, English is already spoken over a large part of the earth's surface and is, of course, the language of those countries which are furthest advanced in the radio art. Broadcasting from a single station to cover an area of many thousands of square miles is not far off, and is certain to be done in English. As my readers doubtless know, the Radio Corporation



Kadel & Herbert

THE HEAVY ARTILLERY OF THE NEXT WAR?

From batteries of portable transmitting stations like this, that can elude capture, propaganda may be hurled against an enemy for the purpose of breaking down their morale—always a powerful factor in war.

of America and the British Broadcasting Company have arranged to put on the air international programs, one from England for America and one from America for England, several nights a week during the coming winter. Both these programs will be heard by thousands of listeners on the Continent of Europe; and it is possible that a similar "transatlantic" program—in English—will be broadcast from Germany with still larger numbers of European listeners.

The broadcasting stations in the Netherlands have found it necessary to have much of their material in English, since they are forced to compete with the excellent programs from across the channel which Dutch listeners-in can easily pick up. Both in China and Japan, the limited amount of broadcasting which is now being done is largely in English. This is because in both countries a majority of the receiving sets are owned not by natives but by foreign residents, nearly all of whom speak English.

Radio has also given a great impetus to the movement for an artificial language like Esperanto or Ilo. Esperanto, for instance, has the advantage over English that anybody, no matter what his native tongue, can pick it up in a few weeks' time, whereas English is hard to learn. Partly in response to popular pressure, lessons in Esperanto have recently been broadcast in France, and prizes offered for the best essays written in that tongue by beginning students. All in all, it is safe to say, therefore, that we seem for the first time in history to be justified in hoping that the age-old barrier of speech may at last be broken down and that radio broadcasting will be the means to this end.

III

EVEN more important, of course, than the speech question is the larger one of the spreading of ideas. If radio does even one-tenth of what is expected, it will result in a far wider dissemination of information about various countries and the ideas prevalent in them, than is at present possible. A cynic might very well argue that this process is likely to make more trouble among the nations rather than less. It is the members of a family, who know each other best, who most frequently quarrel—not strangers living at opposite ends of town. While there is a grain of truth in this observation, it is not important enough to outweigh another very useful factor. The most valuable tool the makers of war have is the fear which people in one country have in those of another. That fear is based upon ignorance which does not realize that all people everywhere are very much alike, all actuated by the same motives and subject to the same human desires. Radio can help, in obvious ways, to dissipate this fear and establish in its place intelligent understanding.

There are some definite emergencies in which radio will serve to mobilize assistance from all quarters at almost incredible speed. Suppose for instance that worldwide broadcasting from one microphone were feasible as it probably will be in the not distant future. Suppose a famine in Russia, an earthquake in Japan, a volcanic eruption in the Caribbean made help urgently necessary. Radio could acquaint the whole world with the necessity, at a speed which seems fantastic even to a generation which is already not unaccustomed to rapidity.

Finally, we must not forget the possibilities of radio as a general educational force. The more people know, the more they are inclined to substitute reason and the orderly reign of law for physical force. I hardly need mention the potential usefulness of broadcasting in opening up a new world of ideas to people who, largely because of the accident of geographical isolation, have hitherto lived parochial and secluded lives.

IV

So much for the bright side of the picture. What about the dangers to international relations which grow out of radio?

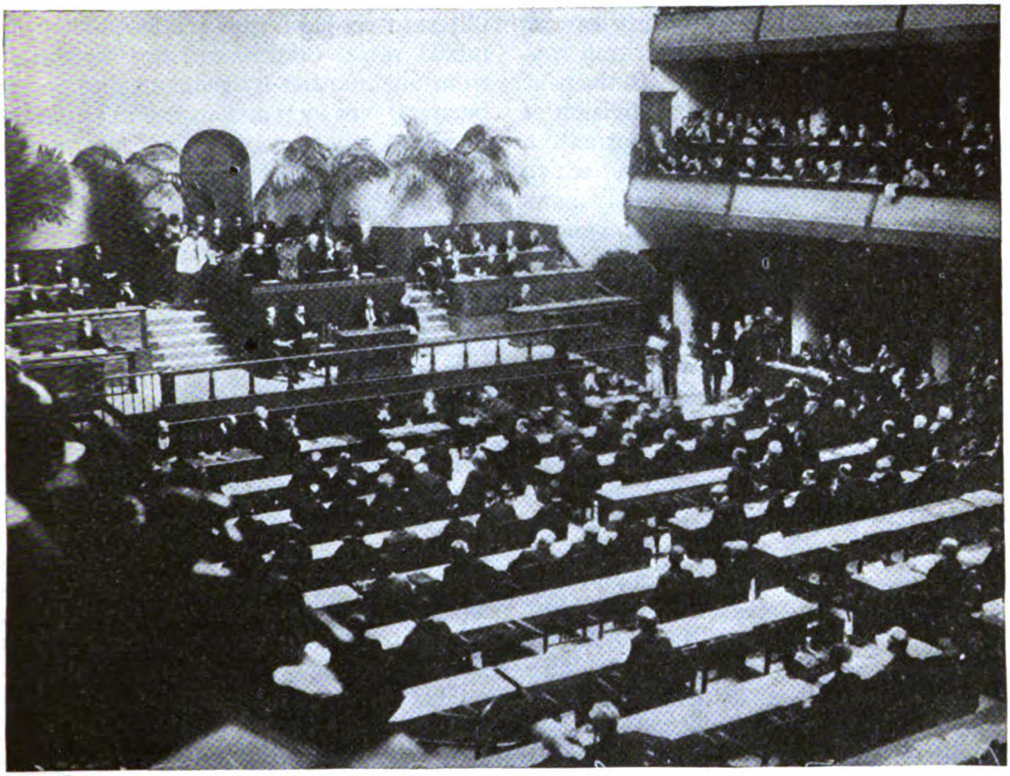
These center about the two distinct aspects, broadcasting and radio telegraphy. For the sake of clearness I shall discuss these separately.

No one can dispute the fact that in radio broadcasting we have the most marvelous instrument for propaganda that the world has ever seen.

Hitherto, the two chief media for getting ideas across to large masses of people have been the printed word and the motion picture. Neither of these in any degree approaches the potential efficiency of radio. They are, compared to it, very slow, extremely expensive and weak and uncertain. Printed matter presupposes a population which both knows how to read and habitually does so. Motion pictures presuppose the existence of theatres and audiences. Even after all this, getting one's "message" into the pages of periodicals, or onto the motion picture screen is so difficult that in many cases it is impossible.

For the propagandist seeking to put his ideas across radio is, technically at least, almost a perfect medium. Where newspapers and motion pictures reach at most a few hundred thousand at a time, radio already has an audience of many millions in the United States, as it soon will in every other country. Radio is instantaneous. While the listeners actually do pay for broadcasting in the long run, they do so incidentally in the purchase of receiving sets. Whatever they pick out of the air seems to them "so much velvet;" and they are, at least at present, less critical than are either readers of periodicals or motion picture spectators.

The radio audience, then, is certain to become the subject of a desperate and



Brown Bros.

A DELICATE EXPERIMENT IN INTERNATIONAL BROADCASTING

Four microphones were used for broadcasting the proceedings of the last meetings of the League of Nations at Geneva; it is now considering the wisdom of broadcasting all of its public debates, in the hope that they will be a force for international understanding. Or will it bring discord?

unending fight by propagandists of every sort, including those who are seeking to bring about a given result in the field of foreign policy—the field which, needless to say, sees the beginnings of nearly all wars.

One of the obvious potentialities is in stirring up public opinion which will help to force a nation's rulers in a given direction.

It is often said that President McKinley did not want to fight with Spain in 1898; but that yellow journalism created a public demand for war which he found himself unable to resist. If the same circumstances should recur—and I am aware of no reason why they couldn't—it might easily be the radio which would play the rôle taken by yellow journalism in 1898. I am, of course, stating what is possible, not what is necessarily likely.

The reply will at once be made that the owners of the broadcasting stations would not permit their facilities to be used for such a purpose. Yet the owners of the stations might easily believe that the propaganda I speak of was altogether right and wise, exactly as the owners of the yellow journals in 1898 believed it was altogether right and wise that we should fight Spain.

V

If radio broadcasting would be useful in starting a war, it would be simply invaluable in keeping one going. I have already referred to the fact that modern warfare requires the united co-operation of all the people in the countries engaged.

This is impossible, as we clearly saw in the Great War, without a spiritual mobilization of the whole nation. In the next struggle, the most important division of the Committee on Public Information will be the Radio Branch, by which censored (and perhaps doctored) news of the struggle will be given out, general orders to the population disseminated and appeals broadcast to the patriot that he shall eat less meat and wheat, leave his car in the garage on gasolineless Sundays, save peach pits for gas masks and buy Liberty Bonds.

Similarly, radio will be used in propaganda behind the enemy's lines. The dispute is still in progress whether the Great War was won by soldiers in the trenches, by starvation or by the American propaganda service dropping leaflets in Germany containing President Wilson's Fourteen Points. While the usefulness of propaganda in breaking down enemy morale is usually exaggerated, it does have its place. In the next war no doubt we shall see portable broadcasting sets mounted on trucks for mobility or concealed in remote mountain fastnesses. From these orators with persuasive voices, speaking the enemy's tongue without an accent, will argue hourly to the invisible audience that they are licked and had better quit while the quitting is still good. Meanwhile, the latter's own broadcasting stations will be laying down a counter-barrage of argument and appeal, or, more likely, will broadcast the dulcet tones of a buzz-saw on the same wavelength to drown out the propagandists' remarks.

This matter is one of great importance for those Oriental and African countries which have long been under the rule of the white man and are today seething with revolt. The leaders of the revolutionary forces in each of these countries are usually men with European educations who have borrowed from the West the ideals of political freedom because of which they now seek to shake off the yoke. But propaganda by the printed word is enormously difficult among these illiterate peoples, who are frequently of mixed racial origins and are separated from one another by religious and social barriers. Not long ago an expert on India estimated that probably half the people in that country know nothing of Gandhi, the great leader in the present anti-English movement. The chief activities open to revolutionists in the past have been making speeches at meetings, which can easily be broken up and the speakers arrested; or circulating small quantities of printed matter which are readily confiscated and are ineffective at best.

But suppose that in India, for example, those interested in revolutionary activity were to buy a small portable broadcasting outfit mounted on a truck, and ten or fifteen receiving sets with loudspeakers. It would then be possible to hold simultaneous meetings in a number of villages. Patriots could assemble in some out-of-the-way corner and hear inflammatory speeches in their own language, broadcast from the portable transmitting station concealed perhaps in the wilderness somewhere near by. The police might be able to break in occasionally and confiscate one of the receiving sets; but the attempt to find the chief conspirators and their broadcasting equipment would be like hunting for one fish in an ocean. In fact, the broadcasting might be done from across the border of a neighboring state, where pursuit and capture would be delayed or made impossible by legal complications. Radio could undoubtedly increase a hundredfold the power of the political agitator even in a country like India or China. The potentialities are even greater in more advanced localities where private radio sets are numerous.

The governments of several nations have begun to display apprehension about these possibilities. In Japan, no station is allowed to broadcast except under direct government control; and no one is allowed to possess a receiving set unless he has obtained a special license. Until a few months ago each set had to

Underwood & Underwood

AN ADVANCE SCOUT IN THE ARMY OF INTERNATIONAL AMITY

Years before broadcasting became known to the public, radio amateurs had been communicating with each other in nearly all civilized countries. This station in New York (2ABT and 2AYZ) has been in touch with amateurs in England, France, Germany, Spain, Italy, Holland, Belgium, Australia, New Zealand, South Africa and the Orient—as the verification cards attest.

be tuned to one wavelength, to receive some one Japanese station and was then sealed; and grave penalties were threatened for tampering with one's set in order to bootleg illicit messages. In several European countries broadcasting is either entirely forbidden or severely restricted and controlled by the government. In India no one can import a receiving set without filling out an elaborate form explaining just why he wants it. Heavy penalties are invoked for building a set of your own without notifying the authorities.

VI

ANOTHER question of an even deeper character is of course involved here. Who owns the air? There is a doctrine in maritime commerce of "the freedom of the seas." May we expect a similar doctrine of "the freedom of the ether?" Or will each country seek to control all messages originating, or received, in its own territory?

Such a policy, of course, would be enormously difficult to maintain, when we have such a situation as that in Europe, where messages broadcast from any one of a dozen countries may be heard in each of the others. This problem will steadily grow more difficult, as the normal range of the ordinary station and receiving set are increased.

I have no desire to pose as a prophet; but I think it altogether probable that the first development we shall see will be a series of mutual defensive treaties arranged by existing governments on their own behalf. Under them each country will guarantee not to permit anything to be broadcast from a station within its borders which is inimical to the interests of the other governments. There is a precedent for such action in existing treaties to prevent the smuggling of arms to revolutionists. There is also a precedent in the terms of the International Telegraph Convention signed at Leningrad (née Petrograd, née St. Petersburg) in 1875. Article I of this convention grandly says that "the high contracting parties recognize the right of all persons to correspond by means of the wireless telegraph." But Article VII hastily adds that the powers "reserve to themselves the right of stopping the transmission of any private telegram which may appear dangerous to the security of the state, or which may be contrary to the laws of the country, to public order or decency."

There is no doubt that most of the existing powers have the will to suppress broadcasting by revolutionaries (unless, of course, it be directed against an unfriendly government). The only question is whether they will be able to do so. Already it is feasible to put on the air "scrambled broadcasting," unintelligible to everyone not possessing a certain special receiving set.

Suppose, for instance, that Soviet Russia were to begin broadcasting communist propaganda in this way for the benefit of receiving sets secretly owned in Western European countries. What could the latter do about it?

VII

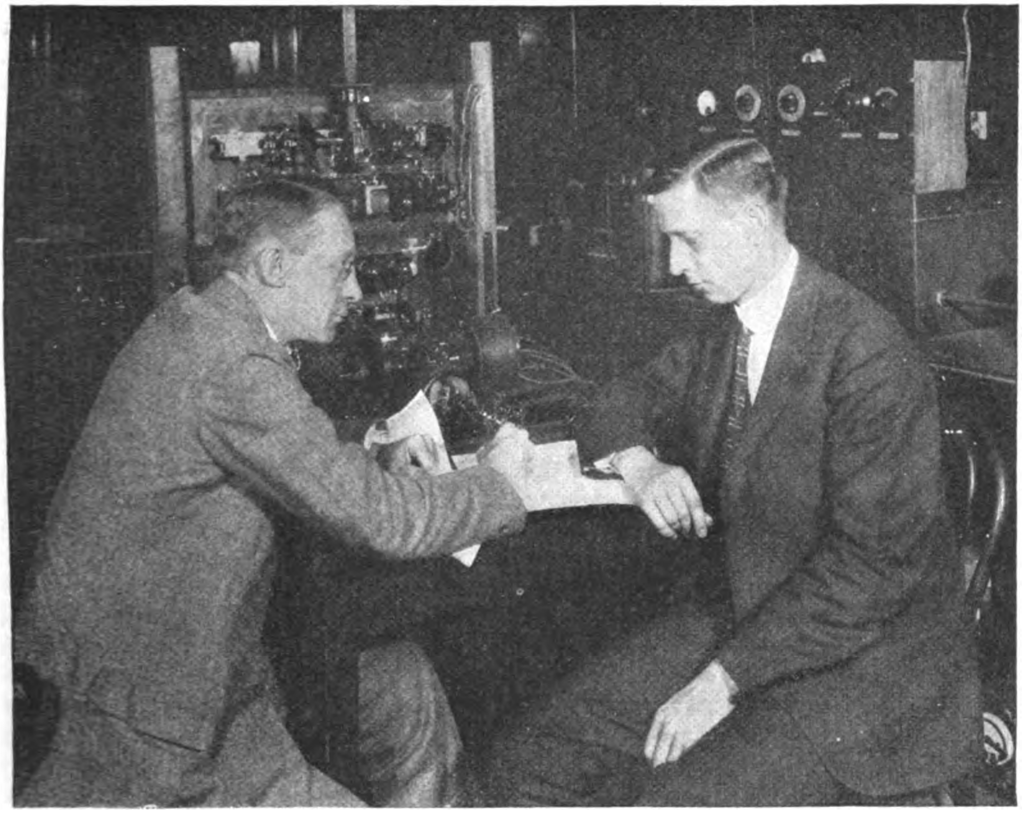
CONTROL of international radio telegraphs is a fertile field for creating disputes among the nations. One of the grievances of the Chinese nationalists is that China has no radio telegraph station of her own. Everything sent out of that country is transmitted by foreign-owned radio or cable companies which, to put the matter conservatively, are always able, whether they do so or not, to exert a censorship in favor of the interests of their own government and against those of China. Not dissimilar conditions exist elsewhere. Viewing the world as a whole, long-distance radio telegraphy is at present almost a British monopoly. The entire British Empire is linked up by a series of high-power stations. Messages from London are relayed to Abou Zabal (Cairo), then to Poona (Bombay), to Singapore and to Port Darwin and Perth, Australia. A branch station at Bagdad picks up Cairo, as does one at Nairobi which in turn, with one relay, gets Cape Town, South Africa. Singapore reaches Hongkong.

France, like Great Britain, has realized the importance of maintaining radio communication throughout her far-flung empire. She has a series of stations which pick up such remote localities as Indo-China and Franch Guiana. Both Britain and France justify these extensive radio telegraphic systems by the plea that they are a useful adjunct to foreign trade. There is no doubt, however, that the monopolistic or semi-monopolistic conditions existing in various parts of the world are a disturbing element in the harmony of the nations and a serious menace in time of war.

VIII

FOR the last two centuries, the world for all practical purposes has been shrinking in size through improvements in the technique of transportation and communication. Radio is accelerating that process more than anything else has done in all history and the smaller the world gets, the more will sheer grim necessity demand that people shall learn how to get along with one another without resorting to large-scale violence in order to settle their differences.

The realization of this fact is certainly one of the most potent forces for peace in existence. And the radio gives an unequalled opportunity, which will inevitably be utilized to a large extent, for spreading this truth among the people of every land.



From a photograph made for POPULAR RADIO

THE CO-AUTHORS IN THE LABORATORY

Since 1916 Mr. H. W. Nichols (at the left) has been in charge of the research in radio communication of the Bell Telephone Laboratories; Mr. J. C. Schelleng has been engaged in similar activities since 1918. These two physicists have been the first to work out the remarkable effect of the earth's magnetic field on radio waves.

How Earth Magnetism Affects Radio Waves

We live on a great magnet. With its north pole located in northeastern Canada and its south pole on the Antarctic Continent, our earth is surrounded by a continual magnetic field, quite like the field around an ordinary bar magnet. In former theories of radio transmission this earth magnetism has been ignored. In this important article the authors show that magnetic effects on the air ions probably have a very significant rôle in long-distance radio. You will be hearing much, this year, of the ideas of polarized waves and magnetic twists, which are here described.

By H. W. NICHOLS and J. C. SCHELLENG

EVERY radio amateur is aware of the great range which is sometimes obtained by the use of short waves.

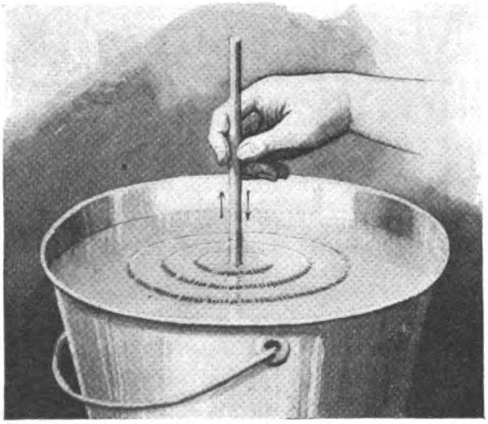
Not many years ago it was thought that short-wave transmission must mean the same thing as short distance transmission since all the experience gained with wavelengths greater than the few hundred meters indicated the general rule that the optimum distance of transmission is roughly proportional to the wavelength. In fact within this range of frequency, the practical rule was evolved which said that it was unreasonable to expect reliable transmission over distances greater than 500 wavelengths.

Now we know that with short wavelengths, satisfactory transmission is often obtained over many thousands of wavelengths with extremely low power.

These observations have usually been qualitative, however, and it is unsafe at present to conjecture to what extent this favorable result is due to superior transmission, and to what extent due to a lower level of atmospheric interference. However, it is not to be questioned that there is a great deal in transmission with short waves which was wholly unexpected a few years ago.

In passing through the wavelength range we find at low frequencies that the attenuation is small; that is, the signal travels with comparatively little loss. At higher frequencies, in spite of the fact that greater radiation efficiency is obtained from the transmitting antenna, the signal is damped out before it has gone as far as the long wave.

It is common experience that long distance transmission within the frequency band allotted to broadcasting is unreliable. Between two points separated by a great distance, it is often found that a one hundred meter wave is received far better than the wave within the broadcast range. The turning point is hard to determine, but it seems to be approximately at 250 meters or thereabout. Furthermore, within this range, fading is found to be most annoying. One is inclined to say that there may be some selective phenomenon taking place in the upper atmosphere which discriminates against this range of wavelengths, and makes it the worst one for long distance transmission.



From a drawing by Arthur Merrick

VERTICAL POLARIZATION

The water wave set up by the up-and-down motion of the stick is an example of a vertical polarized wave. The particles of water vibrate up and down as the wave passes them.

It therefore becomes a matter of importance to see if we are able to find some mechanism which is able to produce these effects at this frequency.

It is generally believed, except perhaps in Germany, that the upper atmosphere contains ions (that is, electrified particles) in sufficient quantities to have an important and usually beneficial effect on the transmission of electric waves.

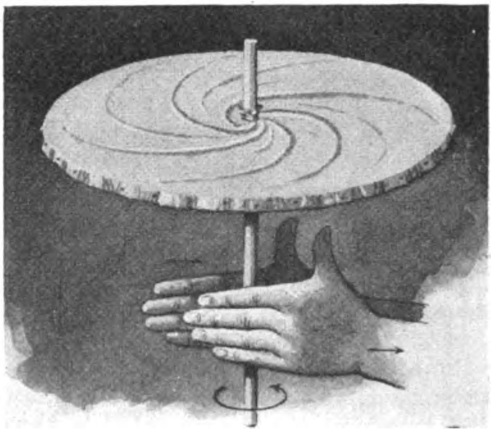
These ions are of course very small. They may consist of several molecules with a small charge. This is the type of ion found near the surface of the earth. At higher altitudes, the number of molecules clustering together apparently decreases, so that at great heights an ion may have an average mass no greater than that of a single molecule. In fact there are reasons to believe that there is also an appreciable number of "free" (detached) electrons. Everyone nowadays is more or less familiar with the fact that electricity itself is atomic, and that the atom of negative electricity is called the electron. It is the flight of electrons through the vacuum which constitutes the plate current in a receiving tube. This particle is very minute, having a mass approximately 1/2000 as great as that of the hydrogen atom.

In 1912, Eccles, an English scientist, developed the theory of ionic refraction. Since that time others, for example, Sir Joseph Larmor, have made contributions along the same line. The purpose of this theory was to show how an electromagnetic wave traveling through a medium which contains free ions will have a velocity which is different from the velocity of the waves in vacuo. The theory of propagation of radio waves is identically the same as the theory of light, and exactly the same methods are used.

We are all familiar with the action of the lens which causes light incident upon it to be bent out of its original path. This is due to the fact that the velocity of light in passing through the glass is less than the velocity of light in a vacuum. This difference is explained in the electromagnetic theory of light by the fact that the glass itself is electrical in nature, the atoms being made up of positive and negative electricity. When the light wave passes through the glass, the electric field of the wave causes the electric particles to move, and this motion of the electricity constitutes a current which produces a reaction on the wave itself. In this way, the wave is made to travel more slowly than it did before entering the glass, so that the direction of the wave is changed if different parts of it travel through different thicknesses of glass.

Much the same thing happens when the light passes through a medium containing free ions. In this case, however, the fact that the ions are free whereas in the case of the glass they are bound by "elastic" forces which are usually very strong, leads to the opposite effect, namely, that the velocity of the wave is greater than the velocity in vacuum. (The velocity referred to above is known as the "phase velocity" and it is different from the speed with which light advances into a previously undisturbed medium. The latter velocity is never greater than the velocity in vacuum, even though this is true of the phase velocity.)

On this theory, therefore, we may regard the atmosphere as having the same effect on the radio wave that a glass prism has on light. At higher altitudes, the number of ions in unit volume is supposed to be greater than at low altitudes, hence a wave will travel faster at the higher elevations than at the lower. This therefore gives a good picture of a way in which a radio wave can bend around the earth. The attenuation of the signal is in part explained by the fact that the moving ions collide with air molecules and hence lose some of the energy which originally came from the wave.



From a drawing by Arthur Merrick

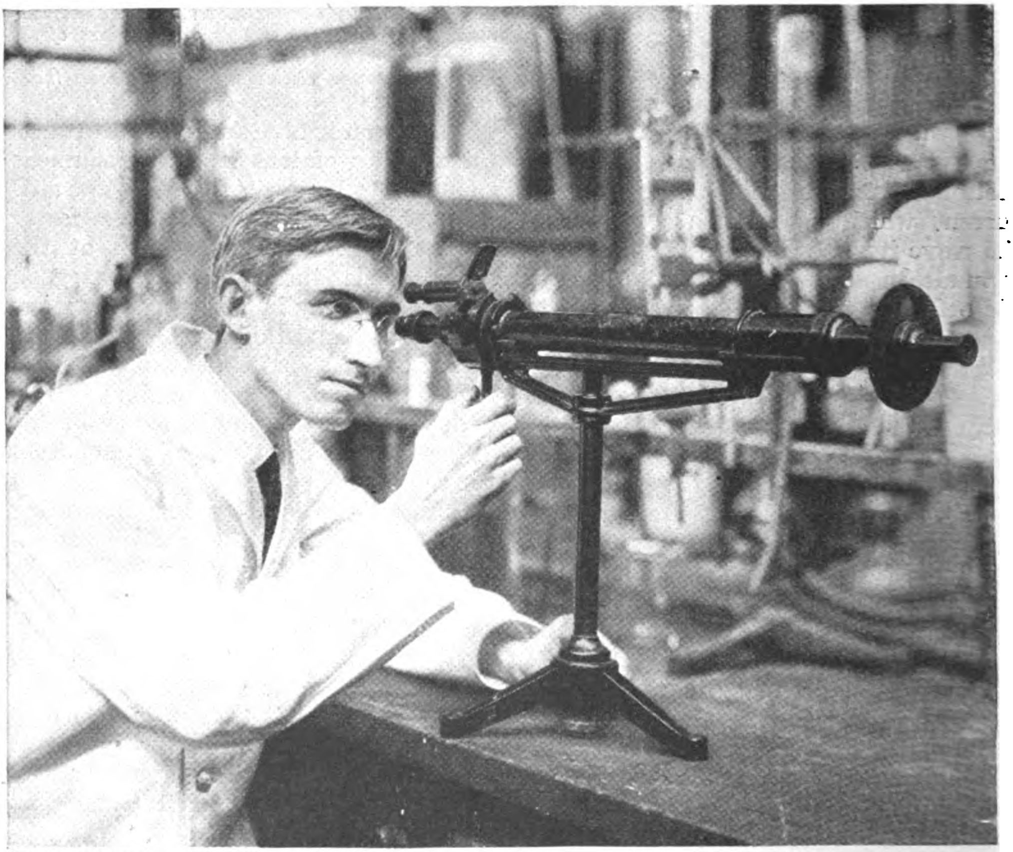
HORIZONTAL POLARIZATION

The stick is attached to the rubber sheet through which it projects. As the stick is twisted a vibration wave is set up in the rubber. It is a horizontally polarized wave; that is, the particles of the rubber vibrate back and forth along the circumferences of horizontal circles as the wave passes them.

It may be seen that there is nothing in this theory which explains the experimentally observed selective effect discussed above. We will now show how such an effect can be produced as a result of the fact that free electrons in the atmosphere are traveling in the magnetic field of the earth. Other ions will effect transmission but will produce no selective effect in the radio range.

It is a fact that when an electron moves in a direction perpendicular to a magnetic field, a force is exerted on the electron perpendicular to the direction of its motion and to the direction of the magnetic field. This is one of the fundamental laws of electricity and numerous familiar examples of it might be mentioned. For instance, it is the principle underlying the operation of the electric motor. The purpose of the field coils of the direct current motor is merely to set up a magnetic field. The armature coils are merely paths through which electrons travel in a direction perpendicular to the magnetic field. Hence, according to the law just stated, a force will be exerted on these electrons perpendicular to the magnetic field and to the wires of the armature. Since the electrons cannot be drawn out of the wire, this force is communicated to the wire itself and causes the armature to revolve.

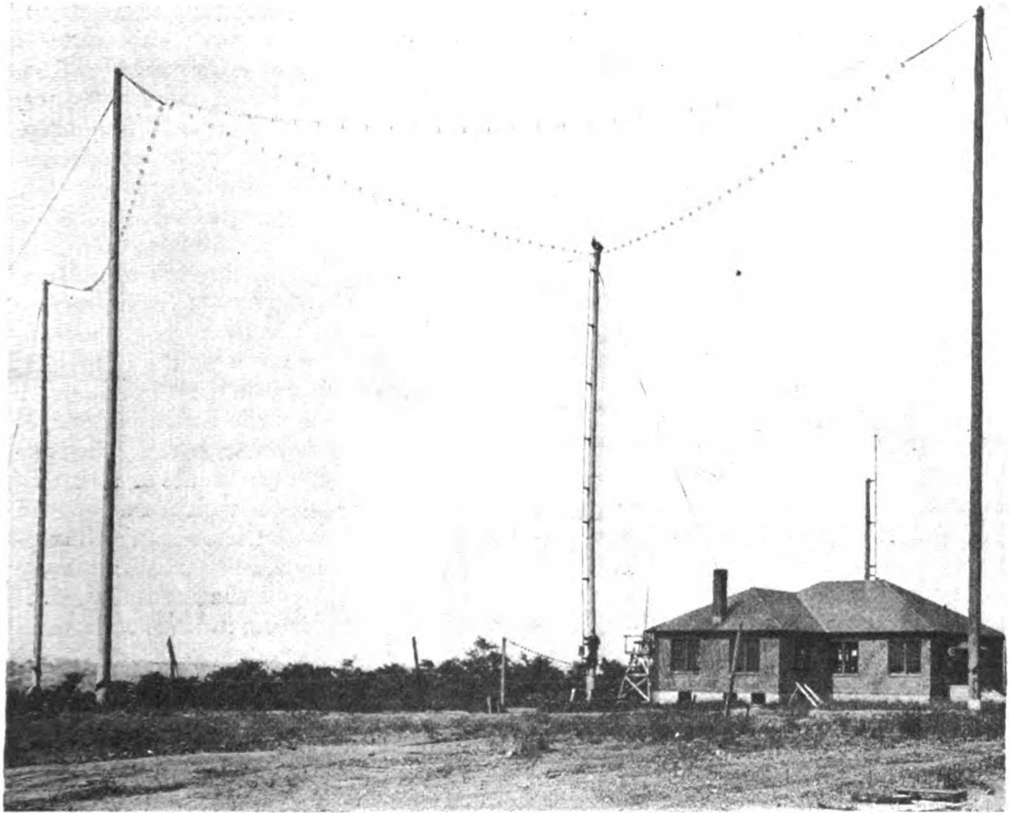
Consider now what happens to an electron when it moves unimpeded in a direction perpendicular to the magnetic field. Since a force is exerted on the electron perpendicular to both its motion and the magnetic field, it will move in a circle (see Figure on page 315) and the direction of motion will always be the same with respect to the magnetic field. If the magnetic field is called H, the charge of the electron e and its velocity v, the force F is numerically equal to $\frac{H\,e\,v}{c}$ in which c is the velocity of light and is equal to 3×10^{10} cm per second. But $v = 2\pi f r$ in which r is the radius of the circle and f is the revolutions per



From a photograph made for Popular Radio

OTHER ETHER WAVES ARE ALTERED BY MEDIUM

Not only are radio waves affected by the ions and electrons in air, but the much shorter ether waves of light are altered by media through which they pass. This picture, made in the Pease Laboratories of New York City, shows a polariscope—an instrument which measures the amount of sugar in a solution by the effect of the sugar atoms on the rays of polarized light.



Westinghouse

A CENTER FOR SHORT WAVE EXPERIMENTS

This antenna system, in use at the experimental station of KDKA, at Pittsburgh, represents one of the antenna types now used for short-wave transmission. The growing mass of data on short waves is proving significant for the new theories of radio wave propagation, including the air-ion and magnetic hypotheses outlined in this article.

second of the electron. Therefore the force is $\frac{2\pi Herf}{c}$. It is proved in mechanics that if m is the mass of a particle, the radial force which is necessary in order to make it travel in the circular path equals $4\pi^2 mrf^2$. Equating the two expressions for the force, we find that $f = \frac{He}{2\pi cm}$. This result is interesting for it shows that the number of revolutions which the electron makes per second depends only upon the strength of the magnetic field.

The earth's magnetic field differs at different parts of the earth and the average is probably somewhat lower than 0.5 gauss; $\frac{e}{m} = 5.3 \times 10^{+17}$. Therefore the electron makes 1.4×10^6 revolutions per second.

An interesting point about this calculation is that the rate of rotation of the electron lies within the range of radio frequency, this frequency corresponding to a wavelength of 214 meters. Since, as stated, the average value of H is somewhat less than 0.5, the critical wavelength will be somewhat greater than 214 meters.

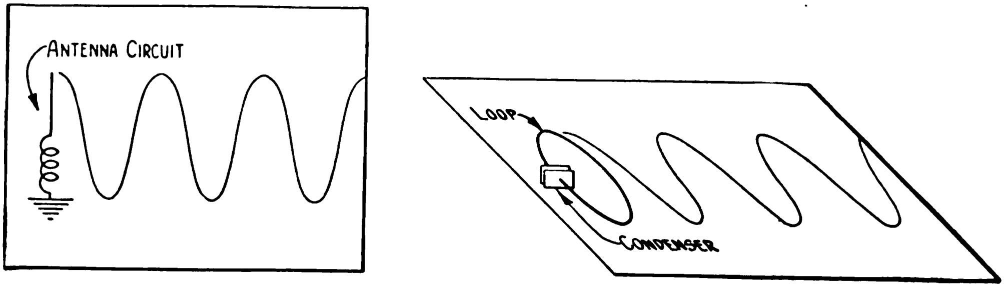
Suppose now that a radio wave whose frequency is 1,400,000 cycles per second passes over the electron and that the latter is free to move without much interference by the molecules of the atmosphere. We have just seen that it is easy for the electron to rotate in one direction about the magnetic field at a rate equal to 1,400,000 revolutions per second. As one would guess, the electron acts in many ways like a circuit which is tuned to this frequency. An electric wave passing through the medium containing electrons will cause them to vibrate and when the frequency of the wave is equal to this critical frequency, the velocity of the electron may become very great. Obviously, this motion will have a pronounced effect on the wave itself and in what follows we will briefly describe some of these effects.*

When the wave travels parallel to the magnetic field, it is in general split into two parts. These two components travel with different velocities, and for frequencies lower than the critical frequency, they are usually refracted in opposite directions. Electrical engineers are accustomed to think of a simple alternating field as made up of two oppositely rotating fields and the same idea can be used in the case of a radio wave. These rotating fields tend to make the electron revolve in opposite directions. But since the latter rotates more easily in one direction than the other, it is natural to expect different transmission phenomena for the two components of the wave. For high frequencies, these two components travel with the same velocity. Near the critical frequency, the velocity of the first component changes rapidly with frequency and the wave is strongly absorbed. At a frequency somewhat higher than the critical value, the rays are in general bent in the same direction. One would expect that when the velocity of the ray changes greatly for a small change in frequency, fading would be pronounced.

A few years ago, the Bureau of Standards in co-operation with the American Radio Relay League made a study of fading, the results of which are given in *Scientific Papers* of the Bureau of Standards, No. 476, by Dellinger, Whittemore and Kruse. One of their tentative conclusions is interesting in this connection.

> "Observations to date indicate that fading is greatest for waves within a certain range of wavelengths and is less for either longer or shorter waves. Fading is more pronounced at wavelengths in the neighborhood of 250 meters than at longer wavelengths. Transmission experiments using 100-meter waves indicate less severe fading than on 250 meters."

There are two causes for the bending of the rays—variation from point to point of the medium in the ionic density and variations in magnetic field. The former is probably by far the more important cause.

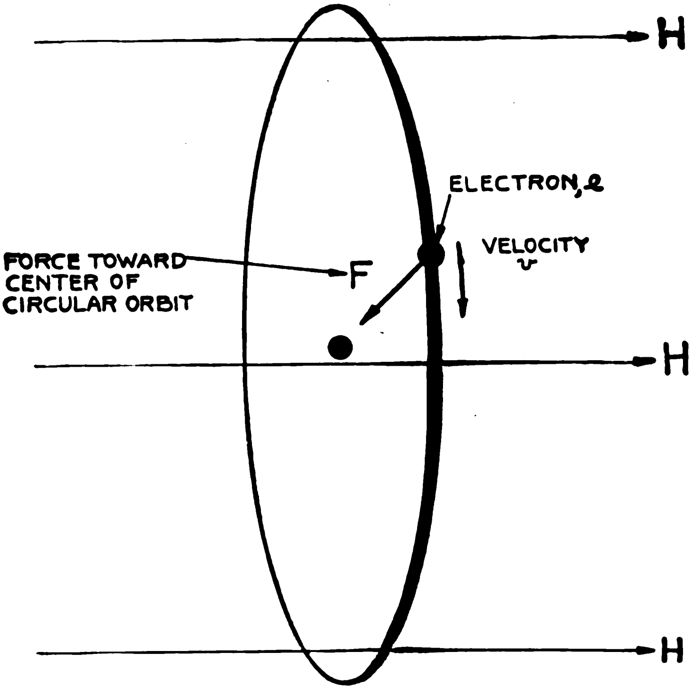


HOW THE KIND OF ANTENNA CONTROLS WAVE POLARIZATION

A vertical-rod antenna, illustrated at the left, sends out waves which are mostly polarized vertically. On the other hand, a wire loop, placed parallel to the earth's surface, sends out a wave polarized in the plane of the loop. This gives a horizontally polarized wave, as is illustrated at the right.

---

* This theory is developed mathematically in the *Bell System Technical Journal*, April 1925, "Propagation of Electric Waves Over the Earth," by the present writers. In 1920 Eccles pointed out that the magnetic field may produce errors in direction finding but made no mention of a selective effect. Appleton independently found the selective effect but calculated that it would occur at 580 meters, later at 350 meters. He has suggested that the term "magneto-ionic" be applied to this theory.



HOW ELECTRONS MOVE IN A MAGNETIC FIELD

When an electron moves freely in a direction perpendicular to a magnetic field, it will not travel in a straight line but in a circle. If an electric wave passes it the electron will have a forced elliptical motion added to the motion produced. H indicates the direction of the earth's magnetic field. It is the reaction of these moving electrons on the wave itself that is responsible for most of the magnetic effects on the direction and intensity of the wave.

Fading on the other hand must be explained by changes in the properties of the medium with time. Again, large time changes of ionic density are more likely than time changes in magnetic field.

Another result of the presence of the magnetic field is that it causes the direction of the electric field of a wave traveling parallel to the magnetic field of the earth to be rotated and this may be a further cause of bad reception since a vertical receiving antenna is affected by a wave only if it is polarized with its electric field perpendicular to the earth. This rotation may also cause errors in the apparent direction of a received signal.

When the wave travels perpendicularly to the magnetic field, it is again split up into two components. One of these is strongly affected near the critical frequency. The other one is not affected by the magnetic field in any way.

Again, in this case, the two rays travel with different velocities and are bent in different directions. Under some circumstances, it is possible for a ray to follow the bend of the earth even though the number of ions is decreasing with height, a statement which applies also to the case of propagation along the magnetic field. It may be mentioned here that the fact that the magnetic field in general breaks the wave into two components which travel along different paths leads to the expectation that they may arrive at the receiving station in different phase and hence destructively interfere with one another. Any small variations in the velocity of propagation along the path of one of these will thus tend to produce fading and this is most likely to occur near the critical frequency.

Another conclusion to be drawn from this theory is that for low frequencies, the magnetic field prevents the electron from moving in as large an orbit as it otherwise would describe. This results in smaller absorption of energy, hence the presence of the magnetic field in the ionized medium may greatly reduce the attenuation under such circumstances, resulting in a greater range than would be found otherwise.

Even when the magnetic field is taken into account, it produces no effect if it is parallel to the electric field of the wave. It is shown in the paper cited that strong absorption is produced at long wavelengths by a small number of electrons per cubic centimeter in the case of such a wave. Such an effect might explain the observation made by Round, Eckersley, Tremellen and Lunnon that transmission across the North and South Poles is difficult or impossible. The observations were made at low frequencies. In these regions the magnetic field is vertical and hence parallel to the normal direction of the electric field of the wave. This phenomenon should be considered with reference to the magnetic rather than the geographic poles but the difference is probably not sufficient to judge between them in the case of the evidence now at hand.

That the magnetic field is of importance in radio transmission is possibly indicated by the observed fact that during magnetic storms (times of unusual variations in magnetic field) radio transmission is abnormal.* However, on account of the small magnitude of these variations in magnetic field it seems more likely that the magnetic and radio phenomena are both results of some other phenomenon (e. g., abnormal ionization due to sun spots) rather than that the first is the cause of the second.

A computation was made of the absorption for the case in which the magnetic field is zero, or negligible because the wavelength is very short. It was found that at that height where the average number of collisions per second made by an electron equals 2^{π} times the frequency of the radio wave; at that altitude there is a maximum of energy absorption per electron. For a given radio frequency there is, therefore, a more or less definite altitude at which this maximum absorption occurs, the altitude being less the higher the frequency because the air is more dense and the collisions more numerous at low altitudes.

Now it has been supposed that ionization increases with height. Might not some new type of phenomenon be encountered when this altitude of maximum absorption per ion becomes so low that even in day time the wave can pass through it without appreciable loss and be bent back to earth by the more intensely ionized region above?

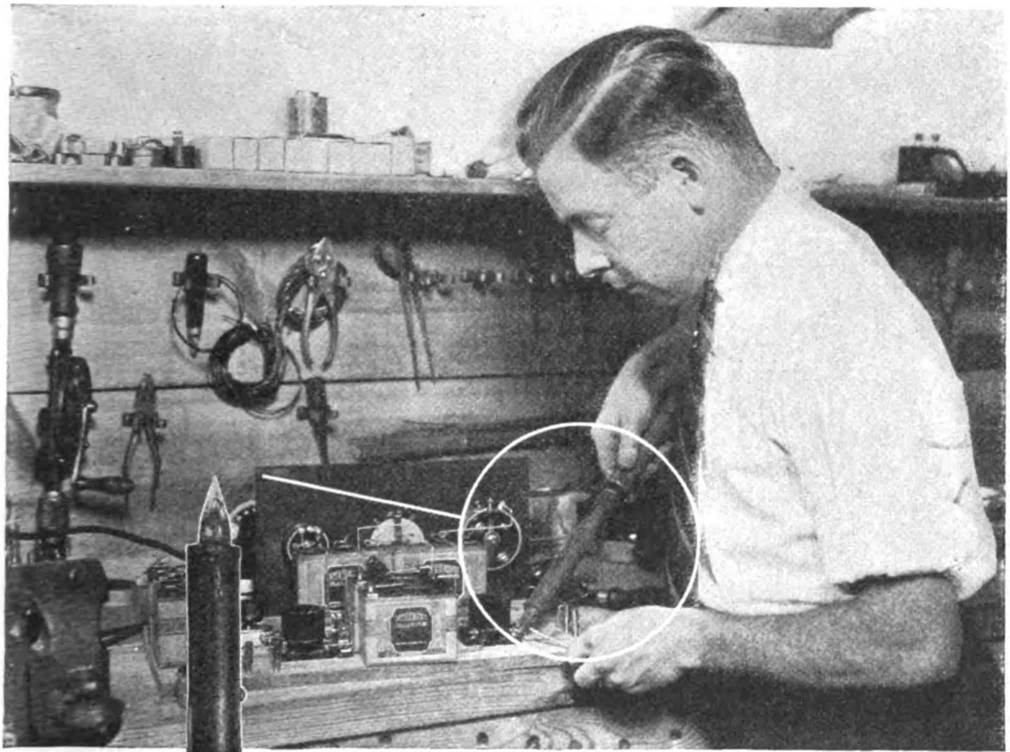
This would provide a mechanism similar to a common conception of the mode of night-time transmission on longer waves, according to which the wave glides along the inside of an ionized sphere as in a "whispering gallery." For short-wave night-time transmission, the reduced ionization after sundown might make refraction impossible, thus spoiling the transmission. This might be used to explain the apparently improved daylight transmission on wavelengths of the order of 20 meters or so.

In passing from long to short waves, transmission at first becomes more difficult for reasons explained by Watson and others. It seems to be most unreliable near 250 meters due to a selective effect resulting from the presence of electrons in the earth's magnetic field. At shorter wavelengths (for example 100 meters) night-time transmission over long distances is improved due to the separation from the critical frequency. At very short wavelengths there is the possibility of improved daylight transmission due to a condition similar to that which favors longer-wave night-time transmission.

---

* *Transatlantic Radio Telephone Transmission*, by Messrs. Espenschied, Anderson and Bailey; paper presented May 6, 1925, Institute of Radio Engineers.

Handy Tools for Radio Fans: No. 7



From a photograph made for Popular Radi

The Electric Soldering Iron

An indispensable tool for wiring

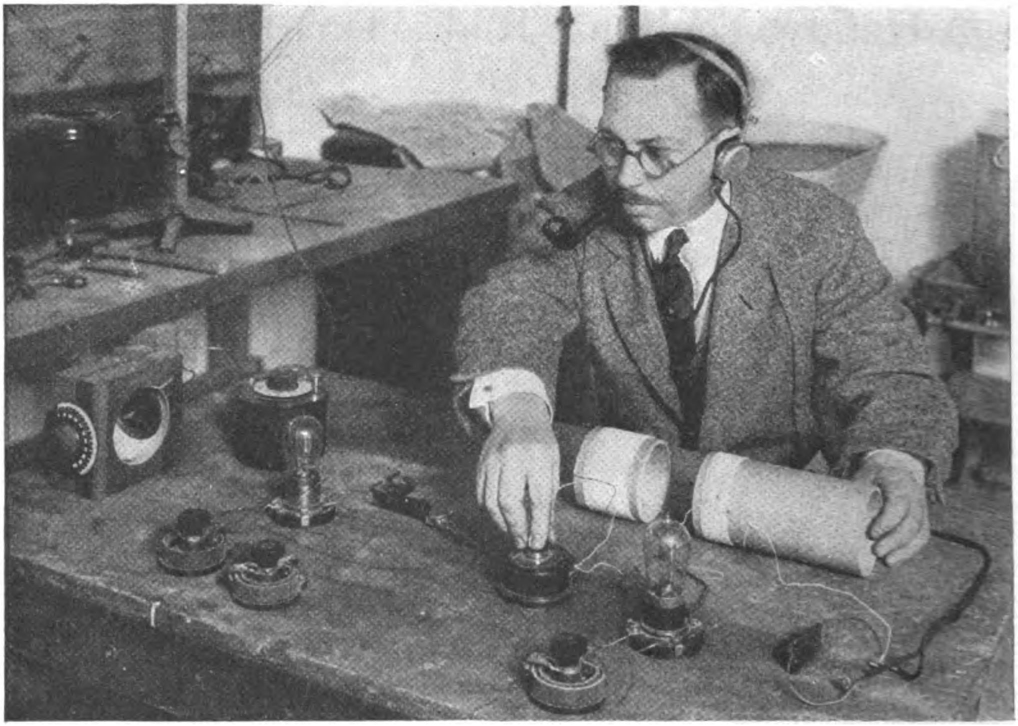
THE radio fan's kit of tools and accessories should include, as one of its most necessary items, the electric soldering iron. With it he can speed up set building and experimental work on new receivers many times in advance of what he could do with an ordinary iron.

The electric iron, if it is a reliable one and properly designed, will remain at just the right temperature for doing a good soldering job on the wiring without damaging the iron or the parts to be soldered.

It eliminates the trouble from faulty joints and large unwholesome-looking gobs of solder that the inexperienced fan usually is bothered with when using the ordinary soldering iron.

With little practice the experimenter can make neat and efficient joints of high conductivity with the modern electric soldering iron.

The preceding suggestions in this series were Side-cutting Pliers, Screw-drivers, the Hydrometer, the Battery-testing Voltmeter, the File, and the Jackknife.



From a photograph made for Popular Radio

The author of this series is one of America's foremost authorities on the theory and practice in radio. This picture shows him at work in his laboratory obtaining the information contained in this series of articles.

HOW TO IMPROVE

Broadcast Reception

VII: How to Reduce Interference

This series of tuning-circuit articles was prepared by one of the most experienced radio engineers in the world *for the special benefit of the broadcast listener.* The preceding five articles of this series include: "The Effects That Occur in the Transmitting Station," August, 1924; "Helpful Hints on Tuning," September, 1924; "Oscillations in the Receiver," October, 1924, "Noises That Come in With the Waves," January, 1925; "Cutting Down Spark Interference," February, 1925; "Increasing the Selecting Power of Your Receiver," April, 1925.

By JOHN V. L. HOGAN

WITH the approach of the winter season of long distance broadcast reception the question of reducing interference once more becomes prominent, for as a result of the large number of stations that are running today the biggest single problem of satisfactory receiver operation is the attainment of high selective power.

In the old days of radio, when relatively few transmitters were in simultaneous operation and when amplification was far from the present high state of development, the question of "getting distance" was mainly a matter of increasing the sensitiveness of the receiver.

That is not the case today, for with the average receiver in the average location the probability is that we shall hear too much transmission—not too much *desired* transmission, but too many unwanted and interfering signals.

In the preceding articles of this series the several sources of disturbing noises were analyzed, and a number of remedies for them suggested. The most pernicious interfering sounds were classed as the "noises that come in with the waves," and among these we have already given some attention to spark or code signals.

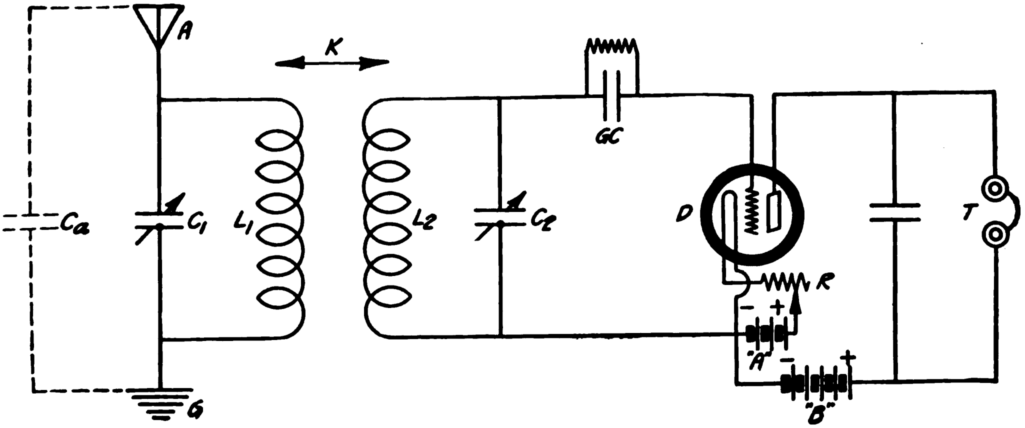
It has been pointed out that although very strong interference from spark transmitters can hardly be excluded, it can be minimized by increased selectiveness of the receiver. Fortunately this increase of discriminating power in a radio receiver will not only aid in reducing code interference, but also will help to reduce "cross-talk" or the simultaneous reception of signals from two or more broadcasting transmitters.

A previous article (which appeared in the April 1925 issue) explained how a reduction of coupling between the antenna system and the detector will aid in getting rid of interference. Simple loose-coupled circuits for crystal and plain vacuum tube detectors were described, and the operation of tuning explained.

Such receivers are typified by Figure 1, which is like Figure 3 of the April article except for a change in the antenna-to-ground circuit. Here the primary variable tuning condenser C_1 is connected directly across the primary coil L_1 and the antenna and ground are connected respectively to the stator and the rotor of the condenser.

Such an arrangement works well with relatively small antennas, and permits one to use identical coils for L_1 and L_2. For the same wavelength the tuning setting for C_1 will ordinarily be a little lower on the scale than for C_2, as the capacity of the antenna is in effect added to that of C_1 as indicated by the dotted lines including C_a at the left of the figure. C_a is intended to represent the capacity of the antenna with respect to the ground, by which approximate amount the value of C_1 must be reduced (as compared to C_2) to bring the two circuits into resonance if the coils are identical.

It is not hard to see that if this circuit arrangement is used with a fairly large antenna it will not be possible to tune the primary circuit to the higher frequencies corresponding to the shorter wavelengths. This is because even with C_1 set at zero the capacity of the antenna system will remain effectively in circuit,



A SIMPLE CIRCUIT FOR SHORT ANTENNAS

FIGURE 1: *This one-tube receiver employs inductive coupling and permits of the use of two similar coils for L1 and L2. By loosening the coupling between the two coils shown at K sharper tuning may be obtained.*

and, in conjunction with the coil L_1, will make the circuit resonate to a moderately low frequency.

There are two ways to avoid this difficulty and thus to keep the two circuits more or less in step.

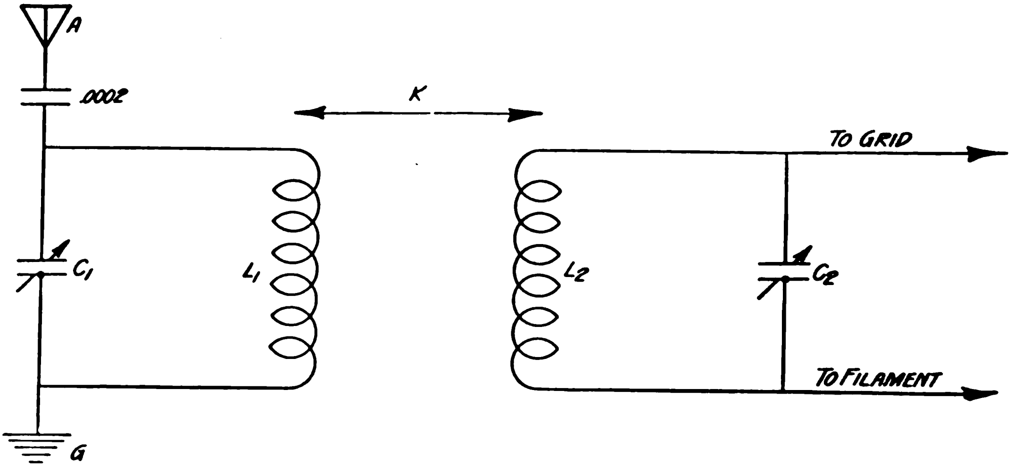
One method is to reduce the size of the primary coil L_1.

The other plan, which is for most purposes the better one, is to insert a small fixed condenser (of about 0.0002 microfarad capacity) directly in series with the aerial as shown in Figure 2. Under these conditions the effective capacity of the antenna-ground system can never become large enough to interfere very seriously with the adjustment of C_1 since it is limited by the small series condenser.

In building a receiver of this type there is considerable latitude for choice of sizes of coils and condensers. For the broadcast waves from 1,500 to 500 kilocycles (200 to 600 meters) the two coils may each be of 60 turns of about No. 22 DSC wire wound on a 3 or 3½ inch tube, and the condensers C_1 and C_2 may each be of 0.0005 microfarad maximum capacity. If smaller condensers are used the coils must be larger to cover the same range of waves, and it would also be advisable to reduce the capacity of the series antenna condenser shown in Figure 2.

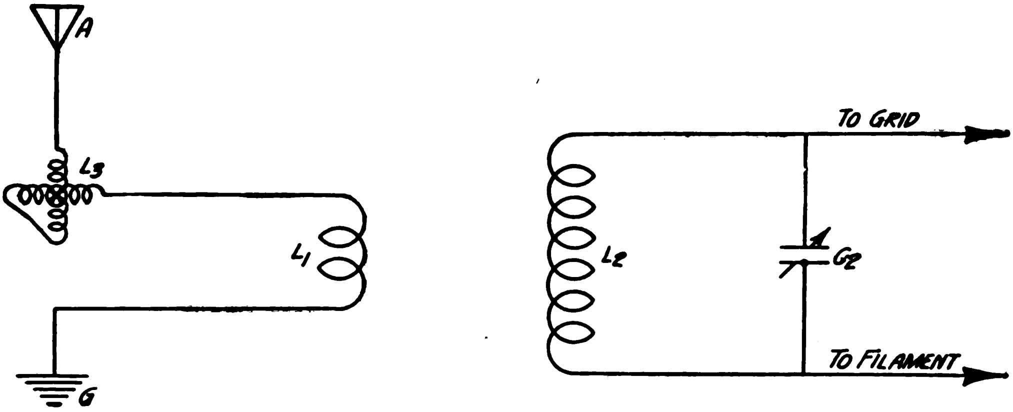
If you have been using direct connected antenna systems, with only a single coil and condenser for tuning, you may expect a great improvement when you change over to the arrangement of Figure 1 or Figure 2, for the loosely coupled two-coil system may be made so selective that the tuning adjustment becomes rather difficult. In fact, this requirement of somewhat skilful manipulation is perhaps the reason that separately tuned antenna systems (with their characteristic increased selectivity) have not been commonly used in radio broadcast reception.

The best way to learn how to handle any of these double-tuned receivers is to follow the procedure outlined in the April article, *i. e.*, to begin with the coils L_1 and L_2 close together and make a list of the best tuning settings of condensers C_1 and C_2 for a number of stations. Then you may separate the coils about an inch and make a new but similar list; the tuning points will usually come a little lower on each condenser scale (for the same stations) when the coils are moved apart, but the first list of settings will aid you in finding the values for the looser coupling. In



THE USE OF A FIXED SERIES CONDENSER IN THE ANTENNA

FIGURE 2: *To eliminate as much as possible the effect of varying antenna capacities on the tuning of the condensers C1 and C2, a small fixed condenser of about .00025 mfd. may be inserted in the antenna circuit.*



A VARIOMETER TUNED ANTENNA CIRCUIT

FIGURE 3: *This system gives very efficient operation for tuning wavelengths that are longer than the natural period of the antenna circuit itself.*

the same way, lists may be made for several additional coupling separations—say two, three and four inches. The greater the distance the two coils are separated, *i. e.*, the looser or weaker the magnetic coupling between them, the sharper will be the tuning of the receiver.

This plan of using the tuned antenna system with well spaced primary and secondary coils is one of the most effective ways of reducing strong interference from powerful nearby spark or broadcasting stations. It does not increase the strength of signals produced by the desired station, as compared to the intensity that could be had with the same receiving antenna when connected directly to the vacuum tube circuit. In fact, for the looser couplings and greater selectivity it will often reduce the strength of signals. But the important point is that the arrangement cuts down the intensity of interference *more* than that of the signals you desire to hear, and consequently makes reception easier and better.

Having once minimized the interference, you can strengthen the desired signals to the greatest practicable amount by adding amplification (as will be shown in a later article) and thus obtain a substantial net gain.

There are a number of variations of the coupled double tuned receiver, all of which give practically equivalent results. Each arrangement has its special advantages for particular conditions, however, and the choice among them rests mainly upon the relation between the size of aerial used and the range of wavelengths it is desired to receive.

The circuit of Figure 1 is particularly adapted for small aerials; Figure 2 permits the same condenser arrangement to be used with larger antennas. The series tuning condenser shown in the April article is generally more desirable for the reception of high frequency (short) waves with moderately large aerials.

Figure 3 illustrates a third arrangement, in which the antenna system is tuned by a variometer L_3, and coupling to the secondary L_2 is provided by a small coil L_1 which may have only five or ten turns. No antenna tuning condenser is used in this circuit, the adjustable element being the variometer; such a system is very efficient for wave frequencies below (*i. e.*, wavelengths longer than) the "natural" of the antenna.

For higher frequencies (shorter wavelengths) a series condenser C_1 of either the fixed or the variable type may be inserted, as illustrated in Figure 4.

In the coupled tuned antenna circuit with tuned secondary, we have, then, a powerful weapon against local interference. Many times it has been found not only possible but easy to eliminate interference from a powerful nearby broadcaster that, with a single-tuned-circuit receiver, produced a constant and bothersome "background" when listening to other stations—simply by adding the tuning condenser and coil in the antenna circuit. True, this arrangement adds one dial that has to be adjusted in tuning; but the improvement in results is almost always well worth the effort.

Fortunately, however, the benefits of this double circuit tuning can be had without adding to the number of tuning controls. By following the plan that I described some years ago,* in connection with a single control receiver for ship-and-shore radio telegraph service, we may tune both the primary and the secondary circuits simultaneously by means of one common tuning element such as a tandem condenser or double variometer.

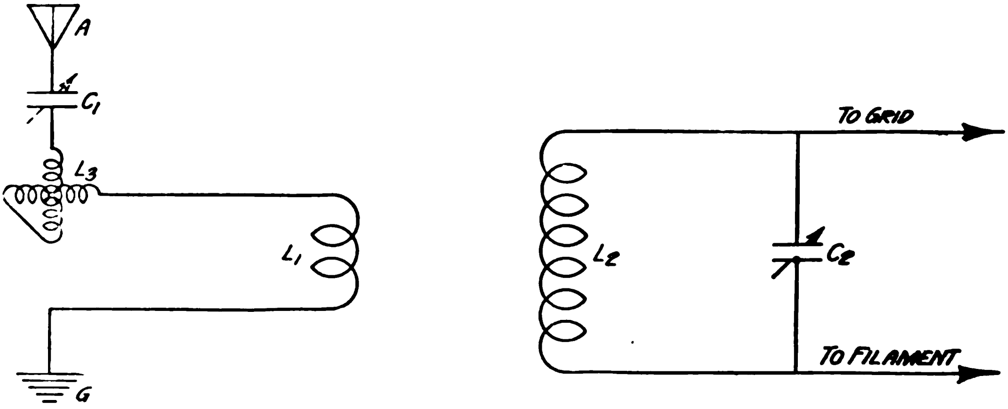
Let us first see how this problem may be solved for use with relatively large aerials, since while the strongest signals can thus be had there is also the greatest need for sharper tuning. The series-condenser circuit is usually the best when broadcasting waves are to be received by means of large antennas. Such a circuit is shown in Figure 5, where, if we are to use single-control, the several tuning coils and condensers must be matched together. Suppose coils L_1 and L_2 are identical, each being made by winding 100 turns of Number 22 DSC wire on a four-inch tube, and that the two condensers C_1 and C_2 are alike in design and both of 0.0005 microfarad maximum. The primary circuit includes C_1, L_1, and the effective capacity of the antenna system which is represented in Figure 5 by the dotted condenser C_a. These three elements are in series, and the whole primary circuit comprising them may be tuned through a range of frequencies by varying C_1.

If we are to make our secondary tuned circuit match the primary, which is important for single control, we will need to have in it two condensers in series. One of these is C_2 and the other C_3. Now, by setting C_3 at a value equal to the capacity of C_a (representing the antenna-to-ground effect), the two circuits may be made to match or equalize and thereafter any equal changes in C_1 and C_2 will produce equal tuning effects in both primary and secondary. Thus, so long as the settings of C_1 and C_2 are alike the two circuits will remain in tune.

Since C_1 and C_2, under these condi-

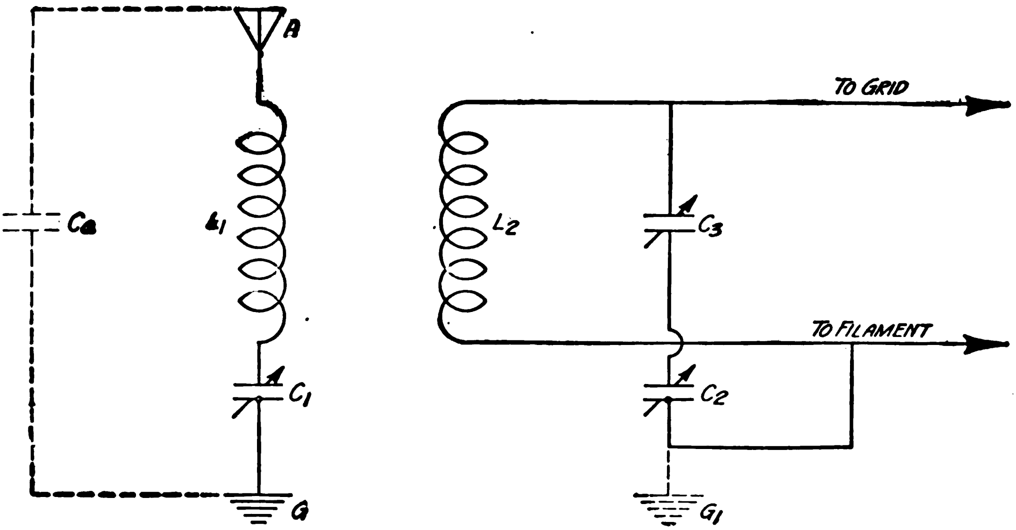
---

*U. S. Patent 1,014,002.



ADDING A SERIES CONDENSER TO THE VARIOMETER TUNED ANTENNA CIRCUIT

FIGURE 4: *This diagram shows how to enable efficient reception of short wavelengths than allowed by the circuit in Figure 3. A small fixed or variable condenser is here inserted in series with the variometer.*



TANDEM TUNING OF TWO CIRCUITS AT THE SAME TIME

FIGURE 5: *This diagram shows the connections for tuning the antenna and the secondary circuits by means of two condensers, C1 and C2. These two condensers may be mounted on the same shaft or they may be a double-unit condenser with both rotors connected together. This effect would be suitable in this circuit as all it would do would be to connect another ground on to the condenser, C2. After tuning in a station with this kind of a tuning unit, the best results will be obtained by adjusting condenser C3 to compensate for the antenna capacity shown at Ca, after which this adjustment may be left set and all further tuning being done by turning the knob that controls C1 and C2 simultaneously.*

tions, are moved practically in unison, they may be replaced by a tandem or double condenser having a single shaft and dial for operating both. If the tandem condenser has the rotors electrically connected together, as is the case usually, no harm will result; the effect is that of connecting the secondary circuit (as well as the primary) to ground, as indicated by the dotted earth G_1 in Figure 5.

To set up and use this circuit you do not need to know in advance what the capacity of your antenna may be. By using matched coils and a well-equalized tandem condenser you eliminate all uncompensated elements except the condenser C_3. If as your first operation you pick up a broadcasting station by careful adjustment of both the tandem condenser (C_1, C_2) and the series condenser C_3, you will quickly and practically automatically find a setting for C_3 at which signals are loudest and which thereafter needs not be changed. If you make this preliminary adjustment with L_1 and L_2 fairly well separated, and if your various circuit elements are properly balanced, you can thereafter tune with the one knob of the tandem condenser.

If the coils and condensers or the other circuit elements are not equalized, their variations may tend to prevent the simultaneous attainment of exactly the best conditions in both circuits. This may be compensated for by using C_3 as a supplementary "vernier."

Figure 1 indicates the tuned secondary circuit connected directly to a vacuum tube detector with telephone receivers in its plate circuit. The same connections may be used with any of the tuned circuit arrangements shown.

In the next article I will describe the single control applied to the small-antenna circuit such as that of Figure 1, and will take up the use of these coupled tuned antenna systems for increasing the selectivity of simple regenerative sets and of radio frequency amplifier receivers.

The MEN WHO

10th Installment

One of the Developers of the Superheterodyne Idea

H. W. Houck *worked with Major Edwin H. Armstrong during the war, and was one of the men responsible for the development of the important superheterodyne idea. In more recent years he has attracted attention by his invention and development of the method of using the second harmonic for amplification according to the superheterodyne principle.*

* * *

Kadel & Herbert

The Father of the Reflex Circuit

William H. Priess *might be called the "father of the reflex circuit." Reaching an early decision that this circuit offered great possibilities for high-quality reception on the broadcast wavelengths, as well as by its familiar economy of tubes, Mr. Priess has stuck consistently to its development, being responsible for the design of several popular types of receiver.*

* * *

The Inventor of the Magnetron

THE *application of magnetic forces to the control of the electron stream in vacuum tubes is the subject with which the name of Dr. A. W. Hull is especially connected. He is the inventor of the magnetron, an electron tube in which the alternating magnetic field of the filament is made to control the electron stream. These magnetrons are used as low-frequency oscillators and as protective devices against surge currents induced by lightning.*

MADE RADIO

The Creator of the High-Speed Finch Relay

PRESENT-DAY *use of radio for the rapid distribution of news and similar telegraphic dispatches owes much to the genius of William G. H. Finch. He is the inventor of the sensitive, high-speed relay used in such devices and which bears his name. Many other devices used in modern radio and telegraph printers have also been worked out by him.*

* * *

A Pioneer Maker of High-grade Condensers

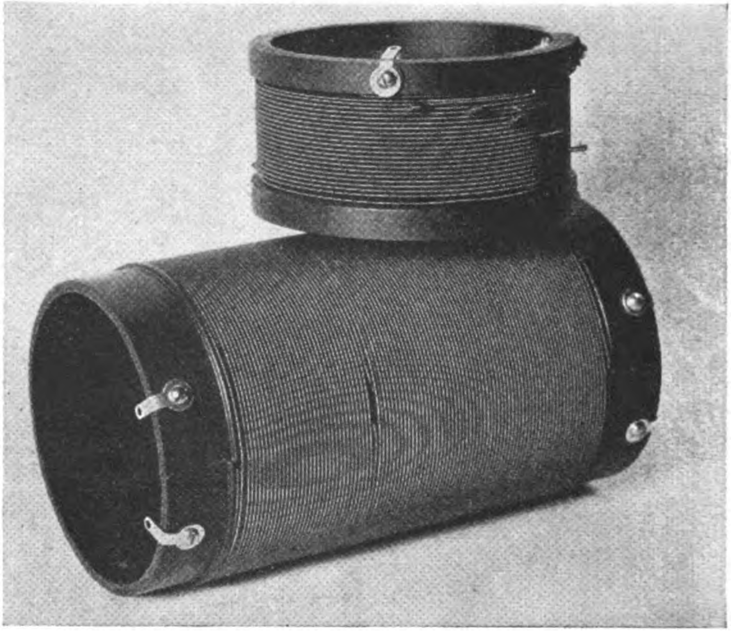
WILLIAM DUBILIER *was a pioneer in the manufacture of high-grade condensers for radio use. Transmitting condensers of his design were used by many of the early amateurs. His name is well-known to present-day broadcast enthusiasts through the small fixed condensers now so widely used, a field of manufacture which he has made particularly his own.*

* * *

A Foremost Expert on Vacuum Tubes

ONE *of the American physicists whose work has been of great importance to radio is Dr. Saul Dushman, of the Research Laboratories of the General Electric Company. Dr. Dushman is known especially for his work on the properties of very high vacuua and on how to obtain these extreme degrees of evacuation. This work has been of utility in the design and manufacture of radio vacuum tubes.*

General Electric



THE SINGLE LAYER SOLENOID IS THE IDEAL RADIO-FREQUENCY COIL

Figure 1: *This type of coil has been shown to have the highest efficiency (together with the one shown in Figure 2) of any of the coils in the following illustrations.*

WHAT MAKES A

Low-loss Coil?

Radio fans and experimenters usually connect the term "low-loss" coil in their minds with some sort of a multi-layer coil which contains no dielectric supporting material. Some interesting facts that prove that this is not the case are contained in this short article by—

CHARLES T. BURKE

THE elusive ohms have been all but driven out of condensers—although a few still lurk here and there.

Now the attention of designers and manufacturers is being concentrated on the task of driving out the ohms that reside in the coils.

It would seem that some of the designers are in league with the enemy, for instead of driving out the ohms, they are actually opening wide the gates and letting a stream of the destroyers of efficiency and sharp tuning pour through their open-work windings.

It is the purpose of this article to point out the places where the ohms sneak in, and straighten out the corners where they hide.

In judging a coil, it is not sufficient to know only the number of ohms that have found their way in and settled down. We must also know the size of the coil, as electrically large coils will always have more ohms than small ones.

The electrical size of a coil, called its inductance, is measured in henries. This name is derived from Joseph Henry, perhaps America's greatest electrical genius. The more henries a coil contains the less serious is a given number of ohms.

The wavelength or frequency, at

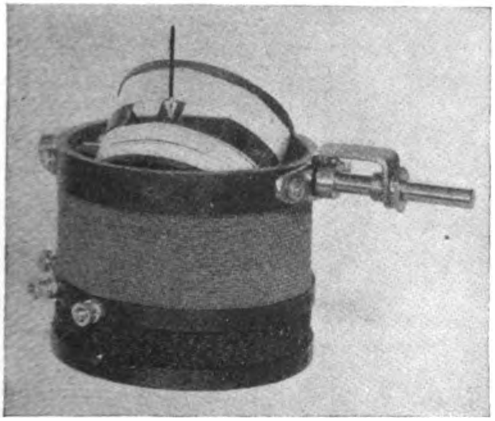
which the coil is measured or used, is also important. The resistance should be measured at some frequency within the band used in broadcasting. The figure often given is the "power factor" of the coil. This is the resistance (ohms) / 6.28 X frequency (cycles) X Inductance (henries). This figure is an actual index of the behavior of the coil in the circuit, and should be as low as possible.

By considering the coil at one frequency, for example one million cycles (300 meters), we can reduce the number of factors that must be borne in mind. The "figure of merit" for a coil then becomes, ohms henries, or ohms per henry. The ohms measured at one million cycles are here used.

Coils used at broadcast wavelengths have much less than a henry inductance, so that they are usually measured in microhenries, just as condensers are measured in microfarads.

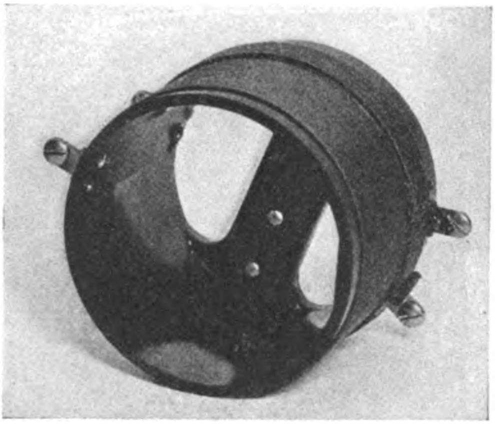
A microhenry is one millionth of a henry. For use with a .0005 m.f. condenser, a coil should have about 200 microhenries inductance.

Another unit, the millihenry is also used. A millihenry is 1,000 microhenries, that is, a 200 microhenry coil has 0.2 millihenries.



A COIL WITH CUT-AWAY INSULATOR

FIGURE 3: *A cut-away coil wound with multi-strand wire that has been found to be almost but not quite as efficient as the straight solenoid type.*

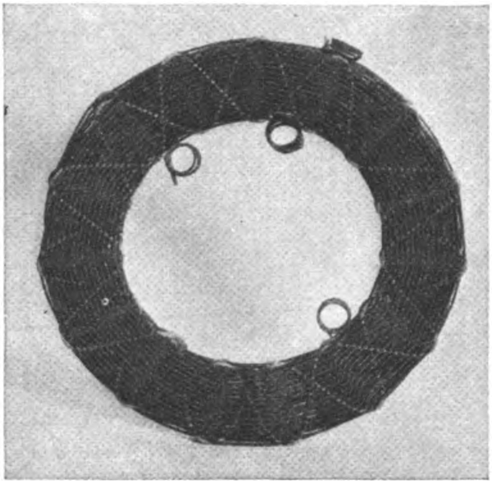


AN INDUCTANCE STANDARD

FIGURE 2: *This type of coil is a standard inductance manufactured by a well-known concern; its efficiency is of the same high order as that shown in the coil in Figure 1.*

Ohms come from several sources. The resistance loss, properly speaking, arises from the reluctance of the metal in the wire to allow a current to pass. It is comparable to the friction in an automobile running on a hard level road. There are other losses, however, that have the same effect as resistance. These are due to absorption of energy in metal and dielectric near the coil. These losses may be compared to the energies wasted by an automobile running through sand. They depend on frequency and on the shape of the coil, as the wind resistance in an automobile does on the lines of the car. They have the same effect as the wire, or friction resistance, that is, absorb power. They are therefore lumped together with the wire resistance and known as the effective resistance. It is these "effective ohms" we must consider.

The wire resistance is the largest contributor to the total ohms of well-designed coils. For this reason the most obvious way of removing ohms is to reduce the wire resistance. Any method of coil construction which increases wire resistance must be viewed with suspicion. Wire resistance increases with the length of the wire and decreases to a certain point as the wire size is increased.



A BASKET-WEAVE COIL

FIGURE 4: *The losses in this form of coil are considerably greater than in the coils shown in the three previous figures.*

Perhaps the first question to be decided in building a coil is the size of wire to be used.

At first it would seem that the larger the wire, the lower its resistance would be. This is not the case, however, when radio-frequency currents are involved. This is because only a part of the area of the wire is then used. The tendency to crowd toward the outside of the wire is more marked in the larger sizes of wire. Currents are also set up in the larger wires that swirl about inside the wire, causing a loss and increasing the effective resistance. Because of this, we find the coil resistance will gradually decrease as the wire size grows larger, until a certain point is reached, when further increase in the wire size increases the resistance. The size of wire where minimum resistance is obtained falls in the lower twenties for the broadcast wavelengths. Measurements show that the hollow is not very sharply defined, and wire as small as No. 26 may be used. For sizes larger than No. 18 or No. 20 the resistance begins to rise.

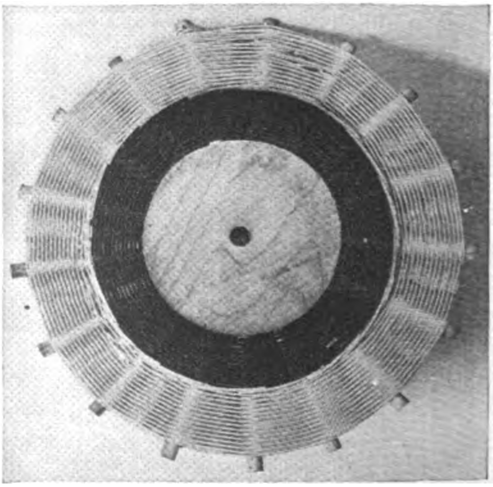
The spacing of the turns also affects the distribution of current in the wire. Near-by wires tend to still further reduce the effective area. For this reason double cotton or silk over cotton insulation is advisable to provide spacing.

The next question that must be settled is the shape of coil.

The inductance is determined by the requirements of the circuit in which the coil is to be used. In order to keep the wire resistance at a minimum, the coil must be so shaped that the smallest possible amount of wire shall be used. The inductance per turn is proportional to the area, so that the cross-section of the coil should be such as will have the greatest area for its circumference. This shape is the circle.

The length of the coil is also important. The leakage in long coils reduces the inductance and makes more turns necessary. The resistance rises in the shorter coils. Experiments show the most desirable length to be about equal to the coil diameter.

So far we have not considered the effect of absorption in the material, or of distributed capacity. The effect of distributed capacity is to slightly reduce the effective inductance, making more turns and more ohms necessary to get



A BASKET-WEAVE COIL ON A FORM

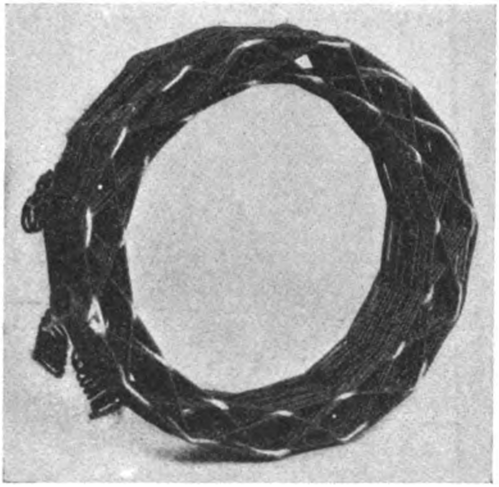
FIGURE 5: *This type of coil wound on a wooden core with radial spokes was also found to be less efficient in a tuning circuit.*

the required inductance. The effect of distributed capacity has been greatly exaggerated. In single-layer cylindrical coils of the type described above, it is almost entirely negligible.

Another source of loss is absorption of energy by the form on which the coil is wound. This loss has also been greatly overestimated. Absorption decreases as the frequency is increased. At radio-frequencies it can be made one of the smallest sources of loss. The reduction of absorption loss is one of the factors that establishes the rule that coil length should equal diameter. This same question was raised in condenser design and gave rise to the metal end-plate craze. Metal end-plates in condensers may introduce as much loss as they eliminate, and hard-rubber end-plate condensers are again rated high among "low loss" equipment.

In coils also, care must be taken lest in trying to eliminate one loss we cause a greater loss. A great number of coils have appeared having various kinds of criss-cross windings that make them self-supporting. As the cross-section of these coils is *not circular*, more wire is required to obtain the desired inductance and loss is introduced in order to eliminate other losses. The question is whether or not there is a net gain. Measurements have shown that when the form (of bakelite) was removed from a cylindrical coil designed along the lines of the ideal cylindrical coil, a barely measurable decrease in resistance was found.

Bearing in mind that the resistance increases in proportion to the length of wire, it seems certain that the increase of resistance when the self-supporting coils are substituted will be more than "barely measurable." This proved to be the case. Some of these coils had as high as twice the resistance of the cylindrical coil.



ANOTHER SELF-SUPPORTING COIL

FIGURE 6: *A special form of multi-layer coil, in which the losses were found to be excessive as compared to the straight single-layer solenoid type of winding.*

Even if the coil has been well-designed, losses having the same effect as resistance may be introduced by metal near the coil. Large terminals should be avoided. Coils mounted on the backs of condensers should be spaced an inch or so from the condenser. The practice of mounting condensers inside of coils is very bad.

To sum up: if you are seeking a coil to give your set its highest efficiency, a dwelling place of "active vigorous henries" rather than a home for "infirm ohms," you will do well to select or wind a coil to these specifications.

When building your coils keep these points in mind:

1. Select cylindrical, single-layer coil, wound on a moistureproof form.
2. The length should be about equal to the diameter. (This permits wide spacing on coils for low wavelength, where it is important).
3. Use wire sizes from No. 18 to No. 28 (the nearer to No. 18 the better).
4. Use small terminals.

By following these rules, the coil resistance may be reduced to less than 10 ohms for the broadcast range of frequencies.

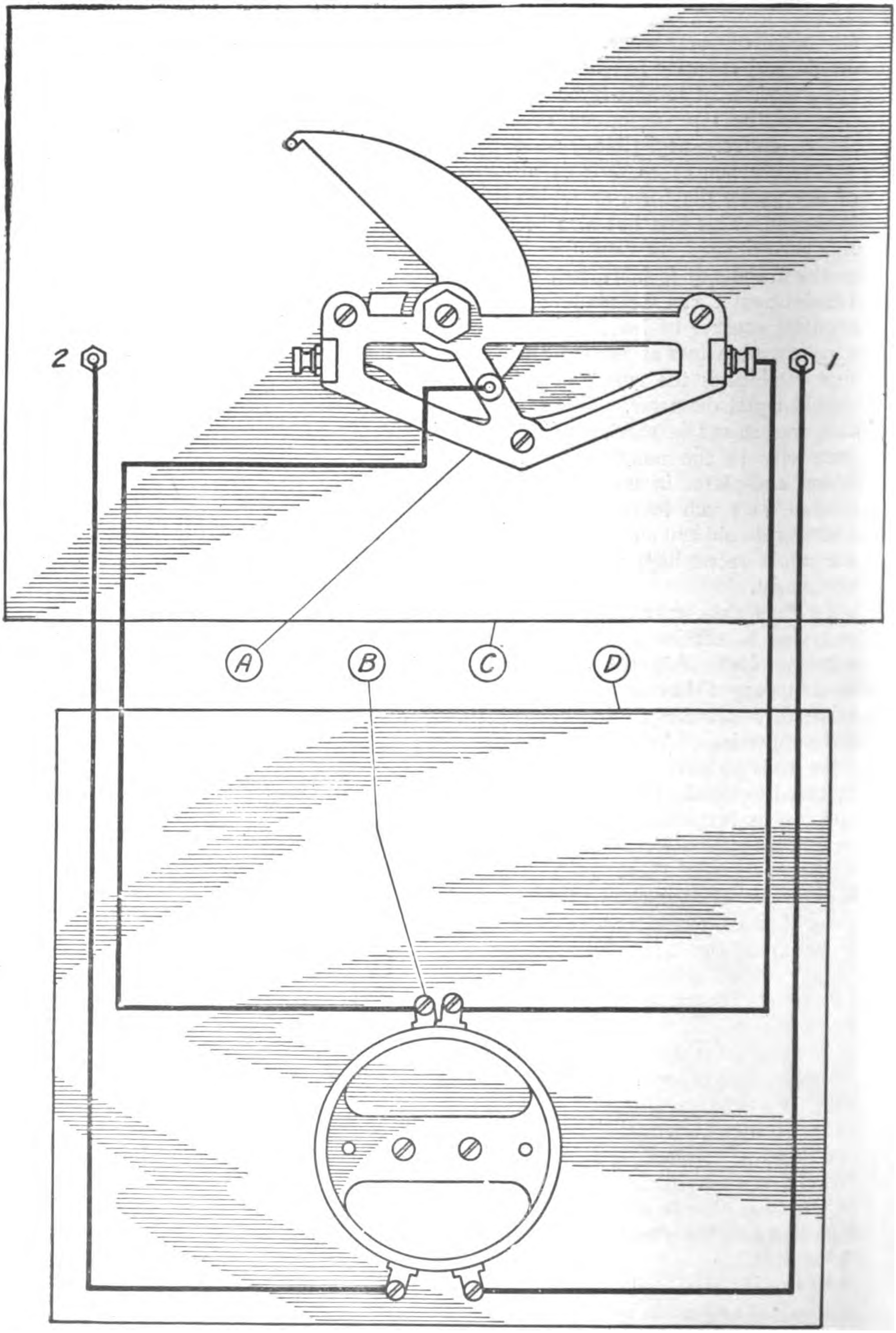
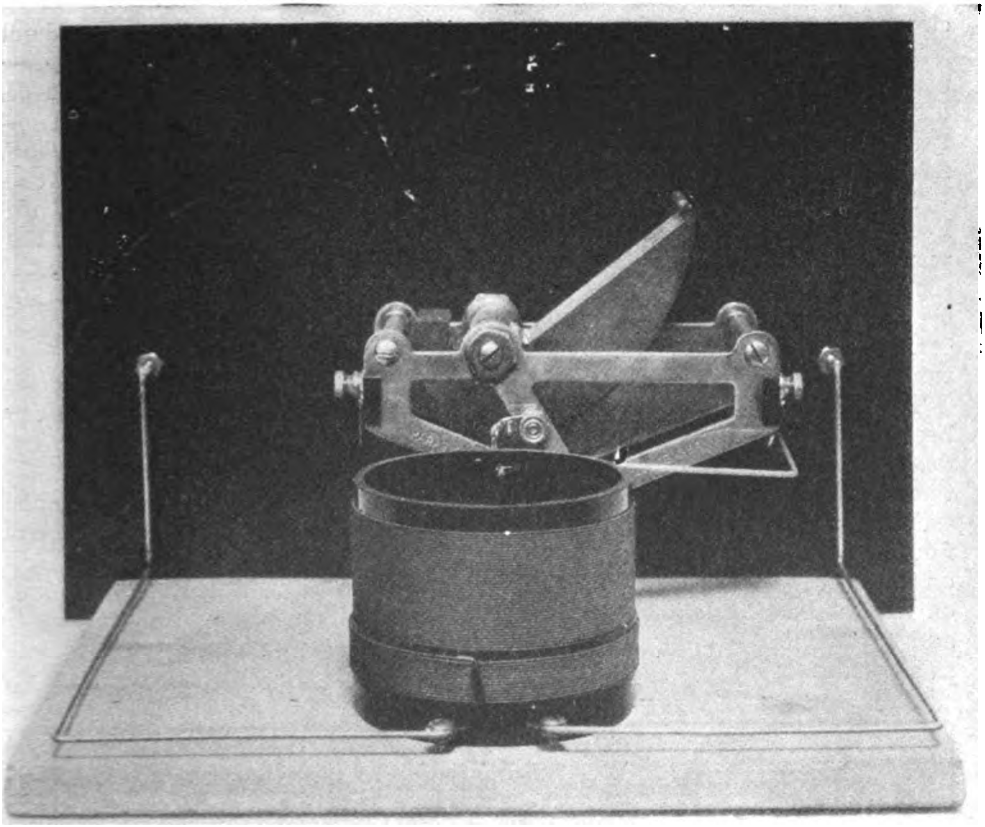


FIGURE 1: *The "picture diagram" of the wavetrap*



THE REAR VIEW OF THE WAVETRAP

FIGURE 2: *This view shows the wavetrap just as it was constructed. It clearly indicates the relative position of instruments and should be studied in connection with the picture diagram of Figure 1.*

Simple "How-to-Build" Articles for Beginners

No. 12

How to build an inductively-coupled wavetrap

By LAURENCE M. COCKADAY

COST OF PARTS: *Not more than $12.00*

HERE ARE THE ITEMS YOU WILL NEED—

A—Karas Orthometric variable condenser, .0005 mfd.;
B—General Radio antenna-coupling coil, 277-D;
C—composition panel, 7 inches by 10 inches in size;
D—baseboard, 7 inches by 8¾ inches;
2—Eby binding posts.

THE twelfth unit to be described in this series is an inductively-coupled wavetrap that is tuned with a straight-line-frequency variable condenser.

This unit has been especially designed to operate ahead of simple detector tuning units in which the tuning is not sharp enough for given locations extremely close to broadcasting stations.

The unit will be found efficient when used with any of the preceding tuners described in this series, or with any other type of receiver in which tuning is not satisfactory.

This particular unit was built in the Popular Radio Laboratory for the purpose of supplying the beginner and the experimenter with details for an efficient wavetrap that can be used in connection with any crystal or vacuum-tube receiver.

Take the list of parts (given at the beginning of this article) to your radio dealer and ask him to supply you with them.

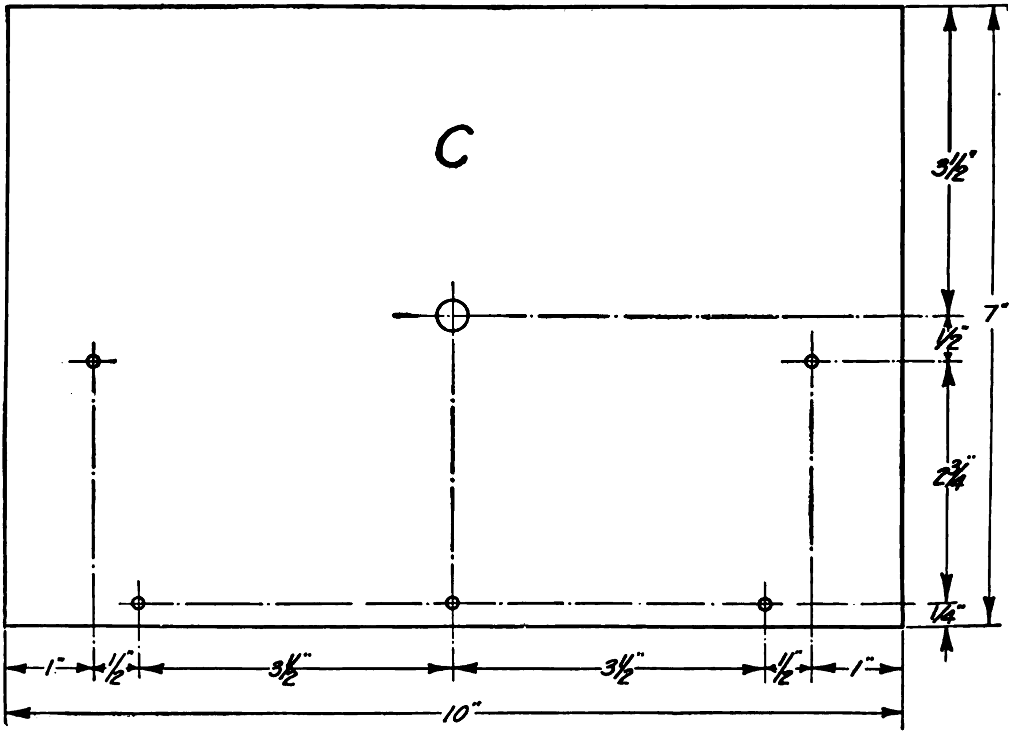
After you have obtained all of them find a satisfactory table or workbench on which to work, and lay out the parts on the baseboard as shown in Figures 1 and 2, after first drilling the panel "C" as shown in detail in Figure 3.

The position for the holes should be marked as shown in this latter diagram, in which the centers for the holes are given.

After drilling the panel, it should be fastened to the baseboard with one-inch nickel-plated screws, inserted through the three holes in the panel into the edge of the baseboard "D." Flat-head screws should be used and the holes in the panel should be countersunk to make a neat job.

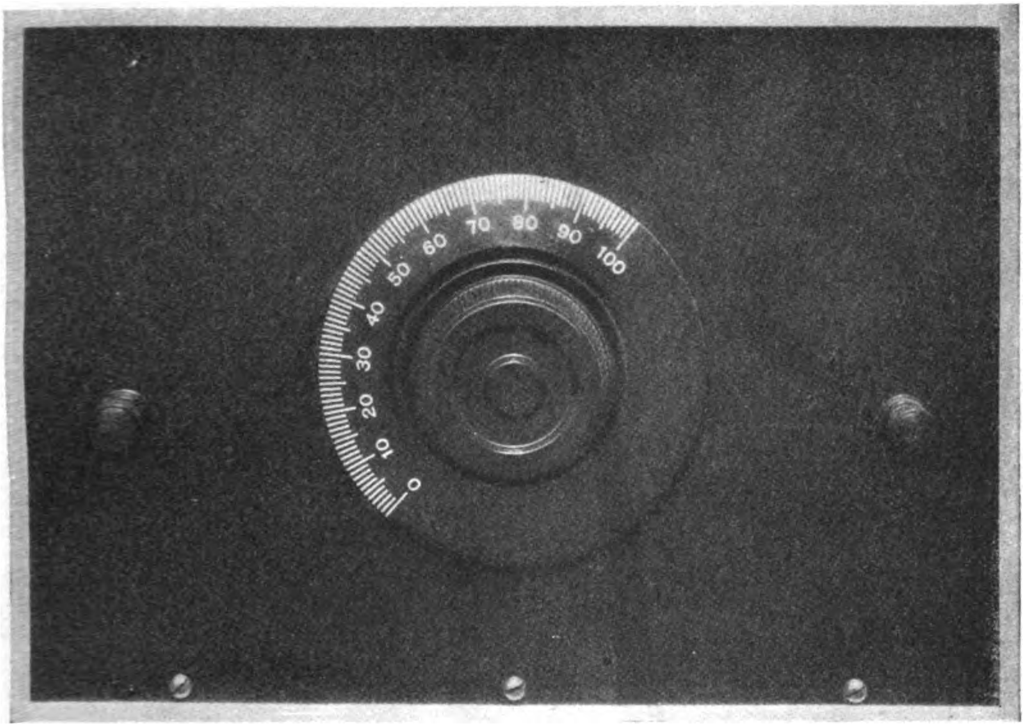
You are now ready to wire the unit and should have no difficulty if the picture diagram in Figure 1 is carefully followed. All parts are here marked with their designating letters which are also used in the list of parts so that there can be no possibility for mistake.

When the wiring has been completed the unit may be set up slightly to the left of your present apparatus, and connected in series with the antenna lead-in



THE PANEL DRILLING PLAN

Figure 3: *This drawing gives the dimensions for the panel and also the exact spacing for all the holes which must be drilled in the panel.*



THE PANEL ARRANGEMENT

Figure 4: *This picture shows the front view of the panel with the condenser mounted in the center and one binding post at each end.*

wire that goes to the set.

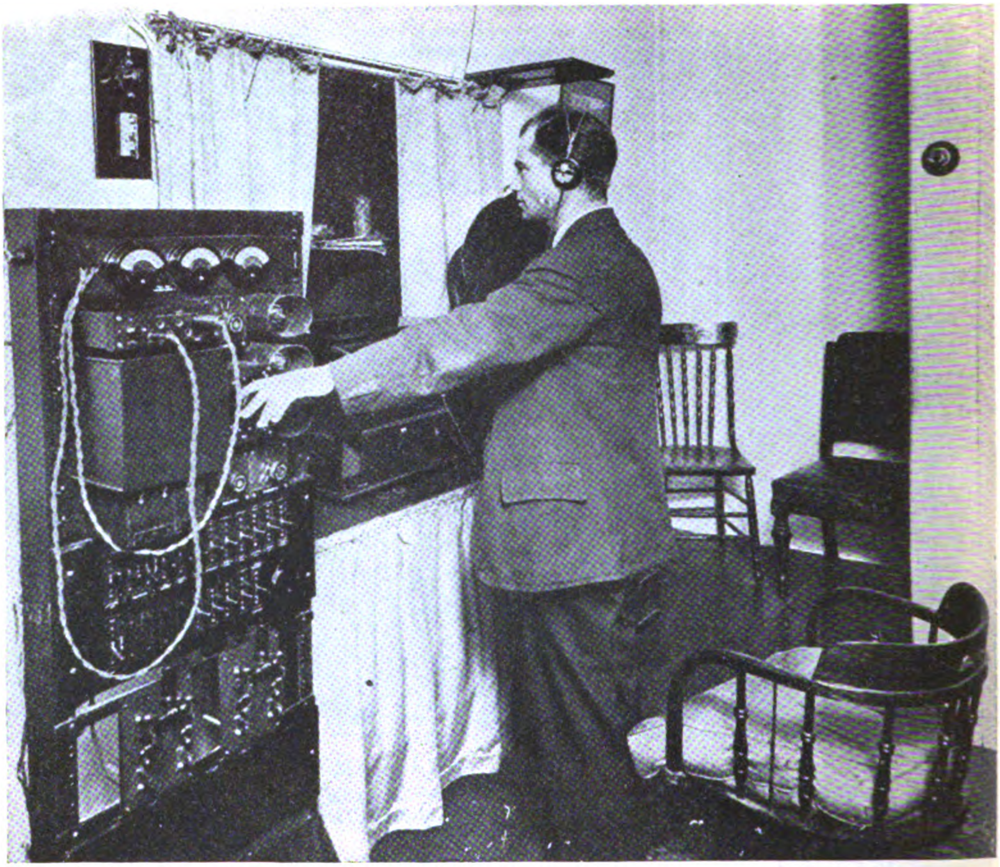
Connect the binding post numbered 1 in Figure 1 to the antenna wire which used to run to your set. Then connect the binding post numbered 2 to the antenna post on the receiver.

By adjusting the variable condenser "A" to a particular setting this unit will tune out any interfering station that gives you trouble, and you may leave it "set" at this point while you tune in other and more distant stations that you want to hear on your receiver.

When this unit is properly built and properly connected, it will provide the experimenter with a tuning element that will help him eliminate much trouble and inconvenience from interfering signals that are transmitted from powerful nearby stations.

The Causes and Cures of "Soured Sounds" in the Receiver

The *next article of the series by Paul Godley (the first of which starts on page 334 of this issue) will tell about the distortion that is caused by improper rectification by the detector, improperly designed amplifier transformers and the overloading of the tubes. The cures of these common troubles are simple—as the author will point out.*



Barratt, London

"MONITORING" A PROGRAM

During orchestral and vocal renditions there are sometimes spots of the program that are too weak to broadcast or too powerful for the modulating apparatus to handle satisfactorily. So an operator listens in on the amplifying circuit and tries to reduce or bring up the volume so that these two extreme limits are never overreached. This picture shows the modulation control apparatus in station 3LO, in Melbourne, Australia.

Secrets of the Studio

How science is solving some of the finer problems in the broadcasting of music

By PAUL GODLEY

TO the majority of fans radio means music of one sort or another.

I believe that pleasant music is the only kind of music that anyone really cares to listen to. What a despicable individual would he be who, during the performance of a great artist, cast upon the ears of those who listened some fiendish spell to sour the harmony! Many radio set builders, unknowingly no doubt, do just this!

Have you ever looked into the funny mirrors at the amusement park? If so, you should be able to imagine what music would sound like after reflection from such a mirror.

Ninety-five percent of all radio listeners hear funny "ear-pictures" of pianos, orchestras, quartets, and voices every day. A great many of these listeners have learned to know the difference for obvious reasons. Yet, given the opportunity, anyone can select the true picture from the cartoon. Even the most unsophisticated ear may be depended upon to turn away from the radio music that now fills many hundreds of thousands of homes when this same music is reproduced there in its *true* likeness. Very few persons would care to give up their radio. But, so many have shown keen interest in the business of improving the quality of music and speech to which they listen that it seems worth while to review some of the efforts being made to supply good radio programs—some of the difficulties which are encountered in doing this, and some of the quite convenient methods recently made available for tremendously increasing the effectiveness of radio programs in the home.

The high tide of broadcast entertainment during the season of 1924–25 was reached when one of the largest of America's musical instrument manufacturers put on a short series of radio programs through a group of broadcasting stations. Scattered over the entire continent, east of the Rockies, these stations were linked together by super-perfect long-distance telephone lines. This series of programs was so well advertised—so much talked about—that the reader has probably already guessed "Victor—John McCormick."

To the music lover the voices of McCormick and the other artists were, alone, enough to entrance. The fact that this experiment might prove of transcending importance to the future of broadcasting passed unnoted by the average listener. On the other hand, there were a few listeners who were able to visualize what was taking place in the studio and actually hear with satisfaction everything for which they listened. The difference between the abilities of the few and those of the average is wrapped up, entirely, in the character of the receiving and reproducing equipment used. It might as well be stated right here that a large percentage of the radio receiving equipment which has been sold to the American public up to this time fails miserably when it comes to the reproduction of sweet music.

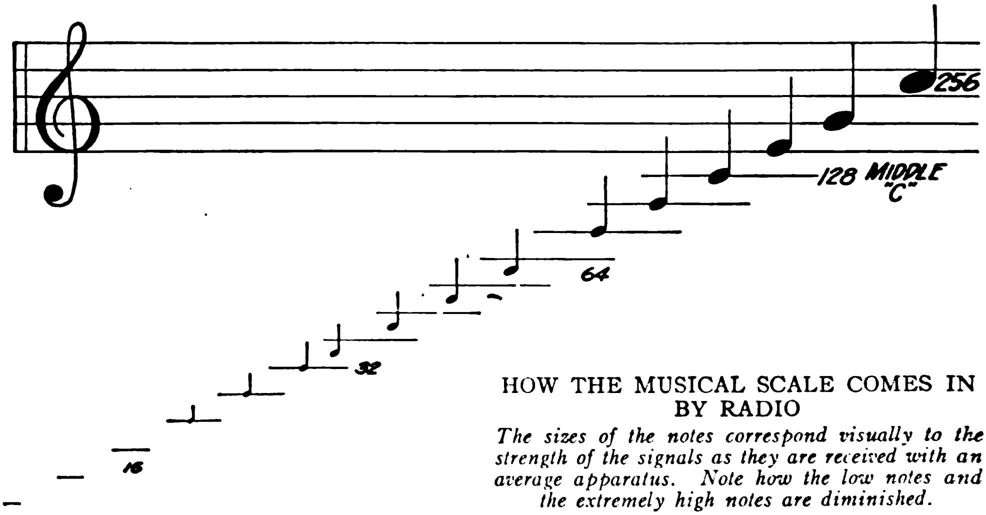
A considerable amount of progress has been made in the art of producing the proper effects before the microphone and in getting these effects onto the air.

There are, of course, different classes of broadcasting stations. Some are well equipped and properly manned by technical experts and are provided with sufficient funds to insure that their work is of the best. Many of the smaller stations, while doing the best with what they have, are unable through lack of facilities to perform with the startling effectiveness of that goodly number of major stations which are now to be found throughout the country.

The first difficulty encountered by the engineer in the faithful transmission of a musical program is that of designing his microphone and its auxiliary voice-amplifying equipment so as to handle effectively all of the tones of the musical scale. This difficulty he has been able to overcome through a careful analysis of the limits of voice-amplifier equipment. Perfect programs are now being perfectly transmitted. When handled with the same effectiveness on the receiving end, quality of tone, the beauty of shading, the actual atmosphere of the studio, and best of all, those certain intangible bits of personality of the artist himself are thrown with uncanny reality into the home of the listener in a way which the most perfect laboratory phonograph ever conceived could not hope to approach.

To those who are properly equipped by experience and with apparatus, an interesting pursuit is that of watching the unfolding of some of the special programs which broadcast stations now offer. Special programs in particular are carefully rehearsed beforehand. A first-class broadcast station nowadays dares not offer an artist without insuring beyond all doubt that the artist and his musical numbers are suited to the radio and to the radio audience. No matter what the reputation of the artist may be, a rehearsal is always insisted upon and invariably that rehearsal takes place in the studio so that the artist may feel at home when he comes before the microphone.

Strange as it may seem, the greater the artist, the more apt he is to lose his poise when his performance begins. Usually he has been trained to sing before a visible audience. He invariably looks for and depends upon the reaction of the audience for inspiration. Before the microphone he pictures a vast throng of attentive, listening people. His inability to see or hear this audience affects him as would a chilly reception. The studio environment—the cold mechanics of the microphone—no doubt encourage this trend of thought.



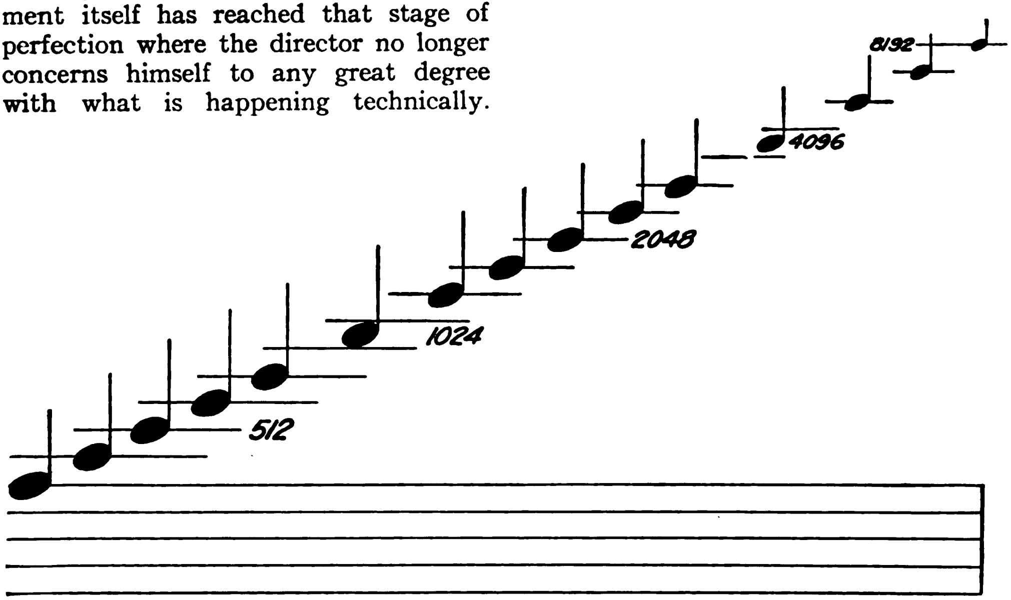
HOW THE MUSICAL SCALE COMES IN BY RADIO

The sizes of the notes correspond visually to the strength of the signals as they are received with an average apparatus. Note how the low notes and the extremely high notes are diminished.

A small group of analysts were listening to McCormick's first radio effort. In the prelude of the orchestra no flaws due to lack of balance of the various instruments could be noticed. As soon as McCormick began to sing, however, the very atmosphere of the studio shrieked that something was wrong. McCormick was unsteady. The volume of his voice was far from satisfactory with respect to that of the orchestra. The balance was poor, and although the selection itself was creditably performed, there was a sense of disappointment to think that with the unusual talent available in the Victor organization and in the organization of the broadcasting station such an unfortunate "hearing" should have developed.

It is interesting to note here how well the observations of these analysts and their deductions concerning what was happening checked with the actual happenings in the studio. The human factor had crept in to spoil the finish of an otherwise beautiful number. McCormick was actually frightened, and although he had rehearsed this number in this same studio before the microphone and reproduced satisfactorily, the actual performance found him a subject of microphone fright. Succeeding numbers showed improvement, due to maneuvers on the part of the directors, such as a change in the position of the microphone. Many of these maneuvers were clearly followed by the critical listeners.

This illustrates some of the finer points with which the directors of radio programs deal. That thing which they fear most is the human element and is, of course, the thing over which they have the least control. The technical development of the broadcasting equipment itself has reached that stage of perfection where the director no longer concerns himself to any great degree with what is happening technically. What actually does happen technically is, of course, very interesting.

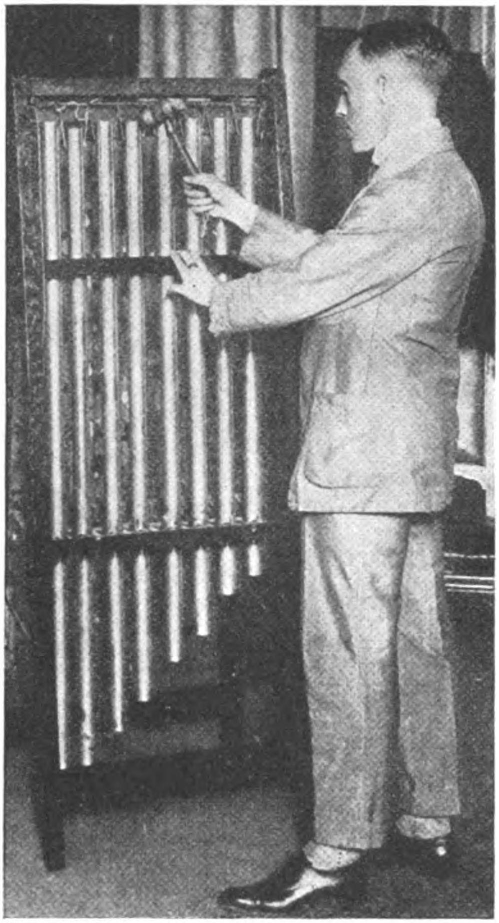


During the few years in which we have had broadcasting, the microphone has been refined considerably.

Microphones used in the first-class stations, although they vary in construction and in principle of operation, are all capable of comfortably handling the required amount of tonal energy regardless of the pitch of the tone. It should be apparent to the reader that for true fidelity of reproduction, the microphone must treat all tones exactly alike. Having accomplished this result it is necessary that all tones should be handled in the same manner by such other equipment as lies between the microphone and the air. Circuits of all descriptions, from the tone amplifiers to the modulator circuits of the high power transmitter working into the antenna, must function without the introduction of tone distortion of any sort. The particular unit in this chain of equipment which has given most trouble is that one popularly known as the audio-frequency transformer, and it is in connection with this device and others that the latest important advances in the broadcasting station equipment have been made. This will be taken up in detail in the second of this series of articles.

In all properly-manned broadcasting stations there is placed at the switchboard an operator who spends his time carefully—or idly—watching the caprices of a small electrical indicating instrument. In the early days of broadcasting the "game" which this operator played was that of controlling the skippings and hoppings of this indicator. On the dial over which the indicator plays perhaps a red mark might be observed. When the needle goes above it, what is known as "blasting" is taking place.

"Blasting" is the overloading of the electrical equipment in the station by the performer. It may come about because the artist has been placed too close to the microphone or because the artist is speaking, singing, or playing with too great volume. Regardless of



Barratt, London

A DIFFICULT FEAT IN BROADCASTING

To reproduce all the harmonics that occur with a selection on the large chimes, is a difficult problem, as the lowest notes of the larger tubes only reproduce in the loudspeaker with a portion of their true volume, as explained in the diagram on the two preceding pages.

the cause the result is the same, and it is easy to foresee some of the effects upon the rendition of various numbers which the efforts of this operator might produce. If a few bars of music are being played softly, and the needle hovers down toward the lower part of the scale, the operator manipulates a control-dial which renders the soft music loud. Contrariwise, if certain portions of the selection are being rendered with vigor it is likely that this operator will soften it to a considerable degree. These operations are, of course, ruinous to the expression which the composer has, at such great pains, instilled into his composition.

There are many radio broadcasting stations which still use this despicable method. It should be abolished. It is wholly unnecessary and is a process painful to the lover of music.

The up-to-date method leaves nothing to be desired in the way of expression. The retention of this expression calls for intermediary equipment capable of satisfactorily handling energies which vary considerably in their magnitude. But, while the operator above mentioned is still watchfully present his duties are more in the nature of an observer of unusual phenomenon. As an augmentation to his efforts a listener with the ear of a musical critic is placed on duty in order that he may take note of the shadings and balance and the many little touches of the maestro which go to make up the superlative in musical creations. He it is who suggests a repositioning of an instrument here or there or a change in the position of the microphone, or the adjustment of one of the draperies on the further wall.

Presumably, it is quite generally known by now that all broadcasting stations are specially decorated. Somewhere, in relating her first experience in the studio of a broadcasting station, one of our well-known artists referred to the studio as a "padded cell." In the past, most studios have literally been this. The ceiling has been covered with felt, the walls with felt or drapery, and the windows with heavy drapery or curtains. The intent has been to prevent any rebounding or echoing from the walls.

The effect of speaking in one of these rooms is rather surprising. The speaker feels as though he were shut away from all earthly contacts. To the temperamental artist this effect is particularly distressing and is perhaps another reason why we have what is known as "mike-fright."

The effect at the listening end, when a

program is coming from a studio of this character, is also noticeable. It can best be likened perhaps to the phonograph record. There is nothing of studio atmosphere to be found in a phonograph record although the effect which the phonograph attempts to produce is that of the "living voice." The radio is, of course, expected to reproduce this effect and in the past perhaps the psychology of the moment, more than anything else, has enabled the broadcasting director to obtain the excellent reactions which he has secured. On the other hand, all radio listeners must have noticed that certain programs seem actually to project the atmosphere of the station into his own home and the thing which lends the most to this reproduction of atmosphere is the transmission of desirable, natural, studio sounds.

A great deal of time and study has been necessary before it was possible for the director to properly differentiate between those studio sounds which are desirable and those which are not. It is now possible for him to do this and in a large measure the "padded cell" idea has been replaced by the proper one where rebounding sounds from certain directions are actually encouraged in order that the natural effect at the microphone may be obtained. The faithful reproduction of all tones and overtones from the very lowest ones of the tremendous pipe-organ to the highest tones of the violin, the subdued echoes of the studio, the bated breathing of the artist or artists, the rustling noises which are always present even with a small group of performers, taken together *are* the atmosphere of the studio and it is predicted that the ability to transmit and receive these minor and heretofore discarded sounds will increase the popularity of radio tremendously.

As pointed out at the beginning of this article, an almost negligible percentage of listeners have to date been able to get these things on their radio and it is not because they are not now being transmitted. They are being transmitted from dozens of stations. The fault lies in the receiving equipment.

Articles that follow this one will point out wherein those deficiencies lie and will provide the reader with the simple instructions necessary to enable him to either revamp his present receiver or provide him with sufficient information to enable him to intelligently select truly modern types of radio receiving and reproducing equipment.

Kadel & Herbert

JAPANESE GIRLS GET INSTRUCTION BY RADIO

One of the business schools for women in Tokyo has installed a loudspeaker in a classroom, in order that its students may benefit from the lectures on radio mechanics that are broadcast from a local station.

From a photograph made for POPULAR RADIO

THE 1,000 CYCLE BRIDGE TEST

The author points out that this method of testing the resistance of condensers with a bridge (at the right) and a standard condenser is inaccurate because of variable factors that affect the resistance at audio and radio-frequencies.

HOW TO COMPARE LOSSES IN CONDENSERS

By SYLVAN HARRIS

BOTH manufacturers and engineers have sought the type of condenser that is most suitable for radio-reception apparatus, but they have neglected facts that have only recently been found; for example, that the resistance of a condenser rises to relatively great heights at the low dial settings. Furthermore, few have suggested that there might be causes of resistance in a condenser other than dielectric absorption, or questioned the generally accepted statement that the resistance of a condenser bears a simple inverse relation to the frequency.

That these miscalculations have been checked by a series of intensive tests, which have extended over a period of several months, is, therefore, a matter of importance to not only the set owner but to the manufacturer as well.

The most common way in which experimenters attempt to compare two condensers is illustrated in Figure 1. Here the two condensers to be compared are C1 and C2. They are connected to a double-pole, double-throw switch so that either one may be thrown in series with a pick-up coil and a current-indicating device, such as a thermogalvanometer. This circuit is excited by electromagnetic waves that emanate from an oscillator shown in the figure.

Engineers have maintained, that, in this comparison, when the condenser with the least resistance is thrown the current in the circuit becomes greater.

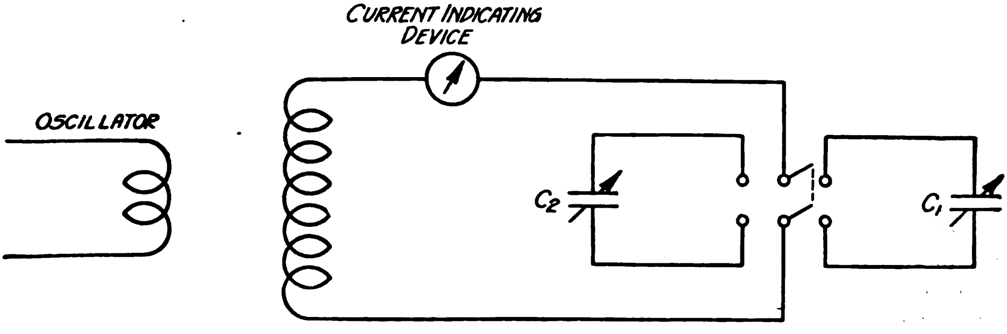
Fundamentally this idea is correct. But, there are technical details which, if neglected, may easily cause errors.

In the first place the condensers must be exactly the same size as regards capacity and dial setting. In the second place, the capacities of the two condensers must be the same at every dial setting. The reason for this primary requirement in making tests is that, since the measurements are made at a constant wavelength or frequency, the setting of C2 may be way down on the dial, while that of C1 may be at the other end of the dial.

Figure 2 shows that in a given condenser the resistance will vary with the setting of the plates, so that a fair comparison of two condensers could not be made unless it were made at the same dial setting. Thus, if C1 were a large condenser, say .001 microfarad, and C2 were a small one, say .00025, for both of them to resonate to the same wavelength with a given coil, the plates of C1 would have to be way out and those of C2 nearly entirely enmeshed.

The next difficulty with this method of making comparisons is the fact that generally the coil used at L has considerable resistance as compared with the resistances of the condensers to be compared. Suppose the resistances of these two condensers do not happen to differ much. Suppose they are .7 and .8 ohm, while the resistance of the coil is 10 ohms and that of the current meter is 4 ohms. Each condenser, when thrown into the circuit, will then be in series with a resistance of 14 ohms. The total resistance of the measuring circuit will be 14.7 ohms in one case, and 14.8 ohms in the other case. Changing from one condenser to the other, therefore, will mean a change of only .1 ohm out of over fourteen and a half ohms, or will represent a change of less than 7/10ths of one percent of the total resistance of the circuit. It is doubtful if, in most cases, this small change in the resistance of the circuit will show up in the current meter.

It has been found in the series of measurements referred to that the resistance of most of the condensers on the market does not differ much. The average of them all is slightly less than one ohm, and the majority of them lie between .7 and 1.5 ohms. It may be seen that, even if condensers are compared by this method, size for size, there may be many disturbing influences pres-



THE SIMPLEST METHOD OF TESTING A CONDENSER

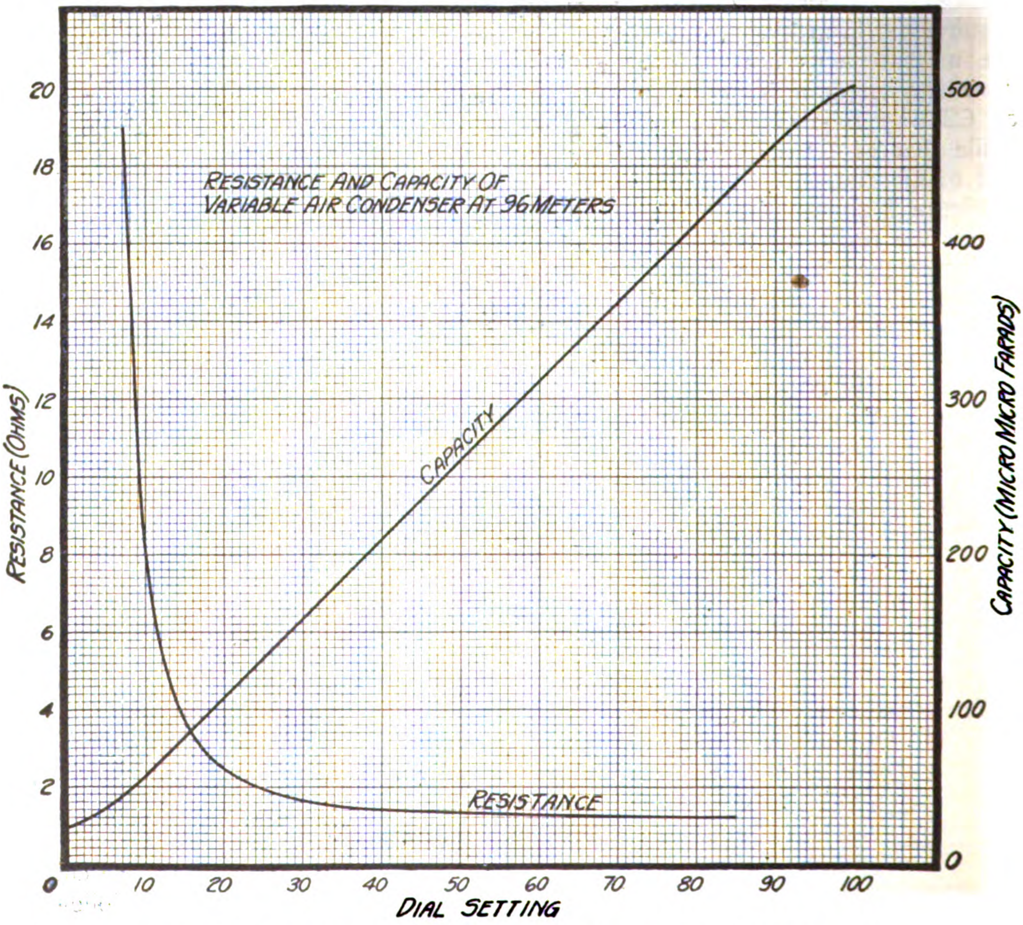
FIGURE 1: *In this circuit the current is supposed to rise when C1 is thrown in series with the pick-up coil circuit, if C1 has a lower resistance than C2 with which it is compared.*

ent which will make such small changes very variable. The solution of this difficulty is the same as with the other method to be described; that is, the resistance of the coil or other inductor in the circuit must be made as low as the resistance to be measured, or lower. Likewise the resistance of the meter must be taken out of the circuit by using a shunt.

A method that has been often used to determine the resistance of a condenser at high frequencies is to measure the resistance of the condenser at a low or audible frequency, say 1,000 cycles, and then to compute what its resistance ought to be at, say 1,000,000 cycles (or 300 meters). This has been done without accurate knowledge of the law of variation of condenser resistance with frequency. Reference to this method was given in the writer's previous article.* The resistance of the condenser is assumed to decrease in the same proportion as the frequency increases. Thus, if the resistance is 300 ohms at 1,000 cycles, its resistance at 1,000,000 cycles is supposed to be

---

* What You Ought to Know about Condensers, POPULAR RADIO, February, 1925; page 129.



THE VARIATION OF RESISTANCE WITH DIAL SETTINGS

FIGURE 2: *These curves show that with a given condenser, the resistance is not the same when two condensers are set differently. This graph shows that no fair comparison can be made except at the same dial settings.*

From a photograph made for POPULAR RADIO

HOW THE ORDINARY CONDENSER COMPARISON IS MADE

This shows the method of Figure 1 in operation. A current measurement with the standard condenser (at the left) is taken while the standard is in the circuit that contains the galvanometer, the pick-up coil and the oscillator on which the man's right hand rests. Then, the DPDT switch is thrown to take a galvanometer reading of the condenser (shown in the foreground) that is under test.

$$300 \times \frac{1{,}000}{1{,}000{,}000} = .3 \text{ ohm}$$

This would be correct if the resistance of the condenser were due only to its dielectric losses, but in this calculation the other losses are neglected.

Figure 3 is a chart which has been drawn from measurements made on a .0005 microfarad variable, air condenser of the so-called "low-loss" type. The horizontal scale has been divided evenly as an axis for the frequency. On account of the great range of the condenser resistance over the range of frequency covered, it was necessary to adopt a logarithmic scale for the vertical axis that represents the condenser resistance. This cuts down the size of the chart as each block (moving vertically) is ten times the block under it.

The actual points measured are A at 1,000 cycles (or 1 kilocycle), D at 3,125 kilocycles (96 meters) and twelve points falling between B and C. The points between B and C, when plotted to a more suitable scale, indicate very clearly that the curve is not linear, and the other points certainly indicate the same thing.

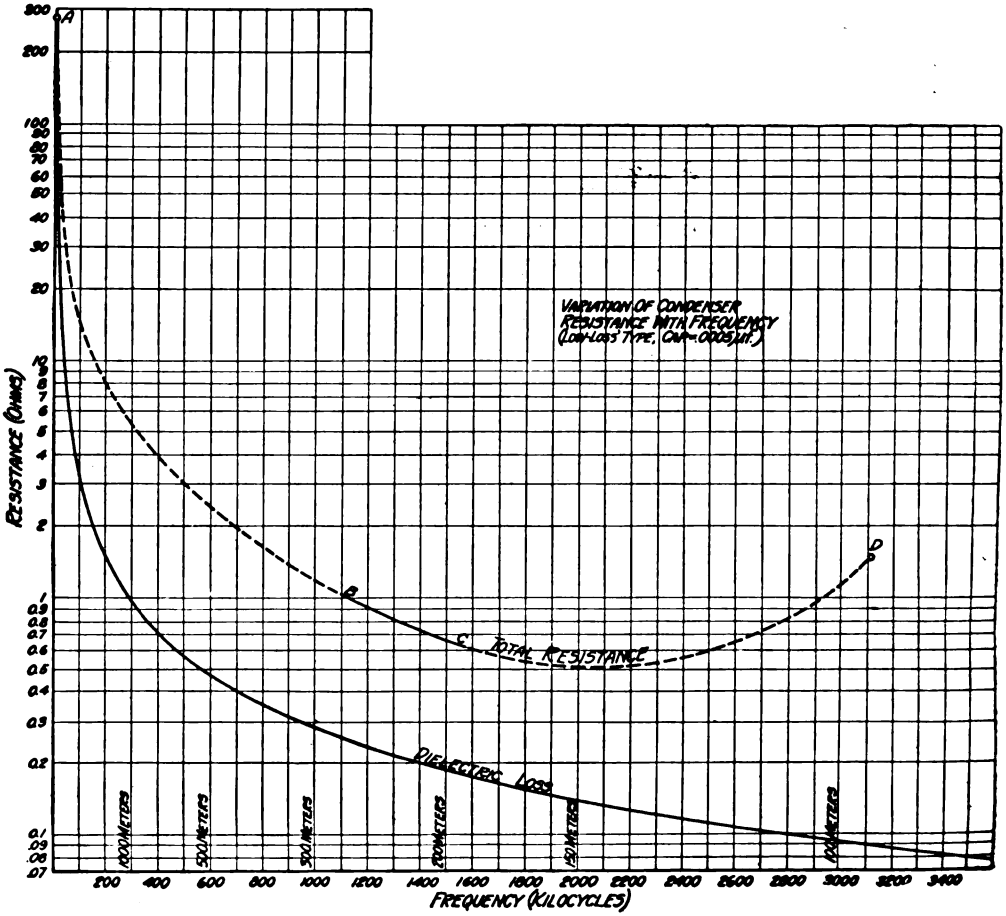
The shape of this curve will no doubt surprise many, especially those who have based their ideas and work on the simple inverse relation between resistance and frequency. This relation is shown in the computed curve marked "dielectric losses," and has been computed from the 1,000 cycle measurement, as explained above.

The reason for the shape of the curve may be explained somewhat as follows:

At low frequencies the losses in the condenser are mainly due to dielectric absorption. Hence the two curves coincide at the low frequencies. As the frequency becomes higher, the dielectric losses decrease in exact proportion as the frequency increases, while the losses due to skin-effect increase at a greater and greater rate. There comes a time, however, when the rate of increase of the skin-effect equals the rate of decrease of the dielectric losses. This is the lowest point of the curve. As the frequency becomes higher, the skin-effect increases more rapidly than the dielectric losses decrease; and hence the curve turns upward.

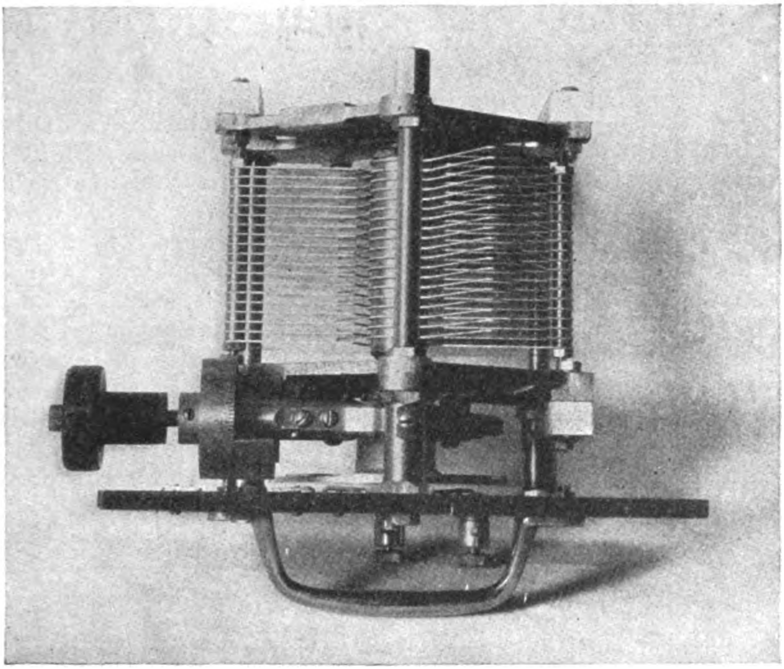
It seems, therefore, that there is an optimum frequency at which the resistance of a condenser is lowest. It was not possible, at the time of making these measurements, to explore the ranges of frequency including the dotted portions of the curve, as the great power required (20 watts) in the oscillator, made it necessary for other activities in the laboratory to stop.

There can be little doubt about the general shape of this curve, although the entire range of frequency investigated was relatively small. There is no doubt about the accuracy of the measurement made at 1,000 cycles (point A on the



THE RELATION BETWEEN RESISTANCE AND FREQUENCY

FIGURE 3: *This curve shows how resistance rises sharply at the lower frequencies and again at the higher frequencies where "skin-effect" increases. Each block in the figure is ten times the block beneath it.*



From a photograph made for POPULAR RADIO

A STANDARD CONDENSER

How a standard condenser looks when removed from its case. This is the apparatus that is used in most comparative condenser tests. The vernier knob at the left makes fine adjustment and close readings possible.

curve) as measurements at low frequencies are very accurate. There is also little question about the various points between B and C as these follow in regular succession and have been checked by measurements made on known resistances of short, straight pieces of very fine manganin wire.

There might be some question about the point D if this were only a single, isolated measurement, but the truth of the matter is that D represents a series of measurements made at the frequency indicated (3,125 kilocycles or 96 meters) as shown in Figure 2, which is for the same condenser at that frequency. Furthermore, the accuracy of point D was also proven by the check measurements.

The curve in Figure 3 should not be taken as giving accurate values except over the solid portion and at the points A and D. The rest of the curve, in broken line, is sketched in to indicate only the general shape of the curve.

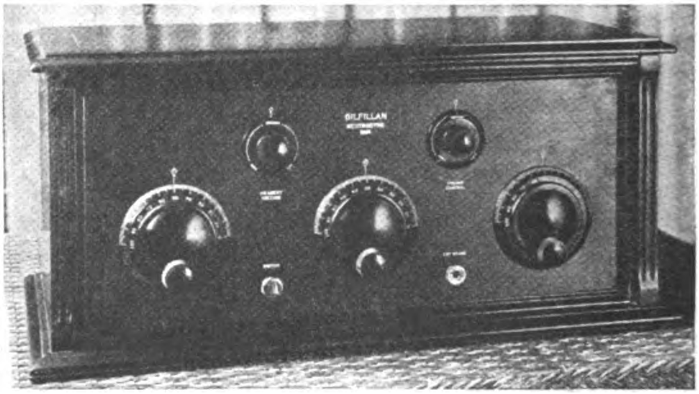
The position of the lowest point of the curve, or the frequency at which the resistance is lowest, will probably vary with each make of condenser. It may be possible for one condenser to have a lower resistance than another at, say, 1,000 cycles, and yet have a higher resistance at radio frequencies.

Although the dielectric losses may be less in the first, the skin-effect in it may increase at a much greater rate. Skin-effect in conductors of electricity is determined by their cross-section, among other things, so that this idea suggests experimentation to determine how the resistance of condensers varies with the thickness of the plates.

These experiments tend to show how worthless, in radio work that employs high frequencies, are measurements made at 1,000 cycles. Even rough comparisons at low frequencies cannot be relied upon, even when we only want to find out which condenser is the better of two.

"What Set Shall I Buy?"

LESS than a year ago there were only a very few ready-made sets on the market; today there are about 140, ranging from small and inexpensive crystal receivers, which sell for as low as four or five dollars, to elaborate superheterodynes that run into the hundreds. Those that have been approved by the Popular Radio Laboratory will be pictured each month until the series is completed. They will be accompanied by brief but specific data concerning them—as a helpful guide to the broadcast listener and to the prospective listener who is thinking of selecting the receiver that will best meet his special needs as well as the limitations imposed by his purse. The data following each of the sets pictured in this series are the manufacturers own specifications and claims; they were obtained through a form of questionnaire sent to all manufacturers of receiving sets approved by Popular Radio.



The Gilfillan Neutrodyne GN-5

Manufacturer's Name: Gilfillan Bros., Inc.

Model; Gilfillan Neutrodyne GN-5

Number of Tubes; five

Type of Tuning; condenser and coil

Type of Detector; vacuum tube

Range on Phones; 2,000 miles

Range on Loudspeaker; 1,500 miles

Cost without Accessories: $110.00

Antenna Recommended; single wire outside, 60 feet long (including lead-in). Not designed to operate on a loop.

Kind of Tubes for R. F.; UV-201-a or C-301-a

Detector Tube; UV-201-a or C-301-a

Detector Plate Voltage; 22.5 volts

Audio Tubes; UV-201-a or C-301-a

Type of "A" Battery; 6 volt storage

Type of "B" Battery; 90 volt

Wavelength Range; 190 to 575 meters

Number of Tuning Controls; three tuning controls, two filament controls;

"A" Battery Current Used; 1.25 amperes

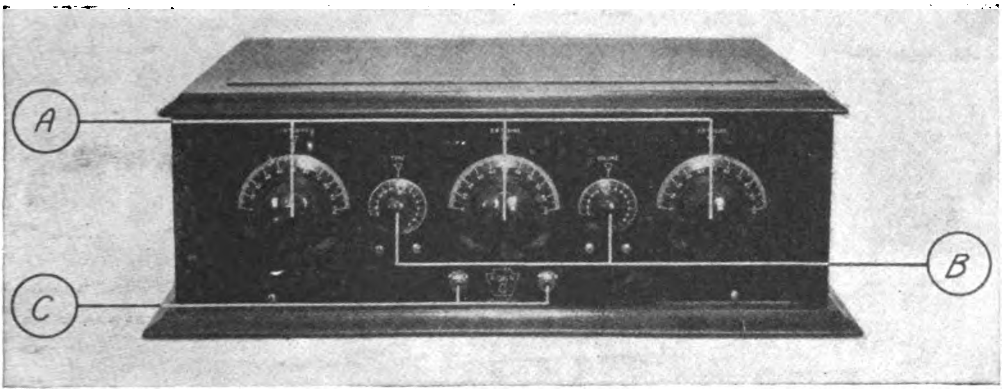
"B" Battery Current Used; 12 milliamperes

Stages Radio Amplification; two

Stages Audio Amplification; two

"C" Battery Used; on radio and audio

Weight in Carton; 35 lbs.



The Penn-C De Luxe Five

Manufacturer's Name; Pennsylvania Wireless Mfg. Co.

Model; "Penn-C" De Luxe Five

Number of Tubes: five

Type of Tuning; tuned-radio-frequency

Range on Phones; same as any good 5-tube set (2,500 to 3,000 miles)

Range on Loudspeaker; from 10 miles up to 3,000 miles

Cost without Accessories; $90.00

Antenna Recommended; single wire, 80 feet

Kind of Tubes for R. F.; C-301-a

Detector Tube; C-301-a

Audio Tubes; C-301-a

Type of "A" Battery; storage or dry cells

Type of "B" Battery; storage or dry cells

Detector "B" Voltage; 45 volts

Wavelength Range; 200 to 600 meters

Number of Tuning Controls; three

"A" Battery Current Used; 1¼ amperes

"B" Battery Current Used; 12 milliamperes when using "C" battery

The Wave Master

Manufacturer's Name; Kellogg Switchboard & Supply Co.

Model; Wave Master

Number of Tubes; five

Type of Tuning; tuned-radio-frequency

Type of Detector; vacuum tube

Range on Phones; 4,800 miles

Range on Loudspeaker; 4,800 miles

Cost without Accessories; $125.00

Antenna Recommended; outdoor, 80 feet

Kind of Tubes for R. F.; 201-a or 301-a

Detector Tube; 201-a or 301-a

Audio Tubes; 201-a or 301-a

Type of "A" Battery; 6 volt storage

Type of "B" Battery; 90 volts, dry cells or storage

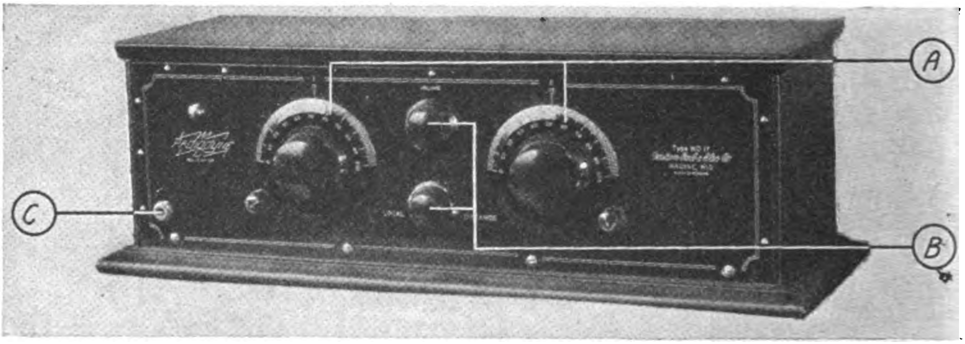
Detector "B" Voltage; 45 volts

Wavelength Range; 170 to 600 meters

Number of Tuning Controls; one

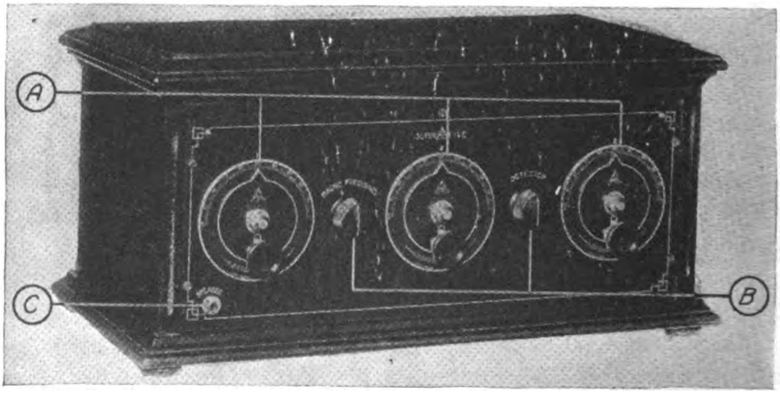
"A" Battery Current Used; 1¼ amperes

"B" Battery Current; 15 to 25 milliamperes



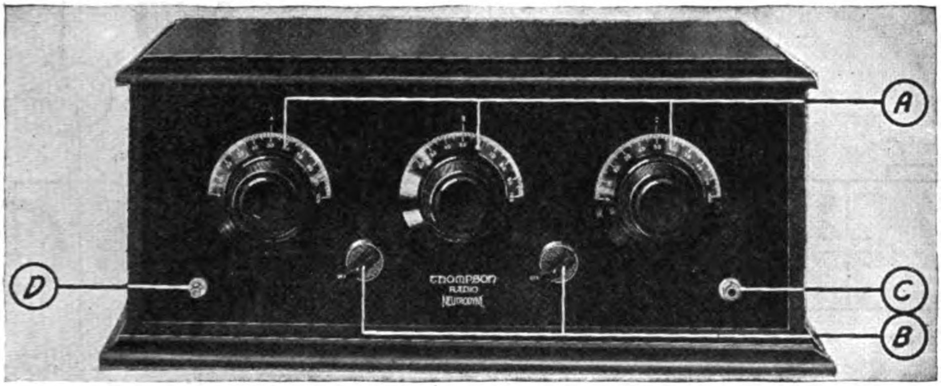
The Radiodyne Receiver

Manufacturer's Name; Western Coil & Electrical Co.
Model; Radiodyne type WC-17-a
Number of Tubes; five
Type of Tuning; tuned-radio-frequency
Type of Detector; vacuum tube
Range on Phones; 2,000 miles
Range on Loudspeaker; 2,000 miles
Cost Complete; $150.00
Antenna Recommended; single wire, 125 feet long
Kind of Tubes for R. F.; UV-201-a
Detector Tube; UV-201-a
Audio Tubes; UV-201-a
Type of "A" Battery; storage, 6 volts
Type of "B" Battery; 90 volts
Detector "B" Voltage; 45 volts
Wavelength Range; 200 to 550 meters
Number of Tuning Controls; two
"A" Battery Current Used; 1¼ amperes
"B" Battery Current Used; 9 to 11 milliamperes



Apex Super Five Receiver

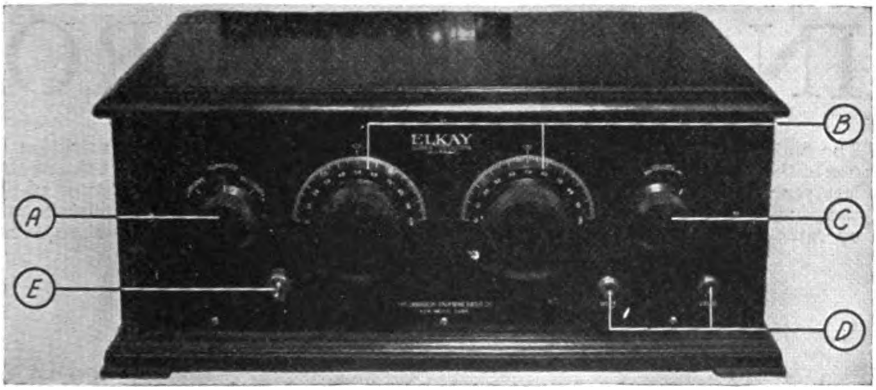
Manufacturer's Name; Apex Electric Mfg. Co.
Model; Apex Super Five
Number of Tubes; five
Type of Tuning; T. R. F.
Type of Detector; vacuum tube
Range on Phones; none given
Range on Loudspeaker; 2,500 miles
Cost Complete; $95.00
Antenna Recommended; 35-100-feet single wire
Kind of Tubes for R. F.; UV-201-a
Detector Tube; UV-201-a
Audio Tubes; UV-201-a
Type of "A" Battery; 6 volts
Type of "B" Battery; dry or storage
Detector "B" Voltage; 18-24 volts
Wavelength Range; 224-556 meters
Number of Tuning Controls; three
"A" Battery Current Used; 1.25 amperes
"B" Battery Current Used; 20 milliamperes when "C" battery is used



The V-50 Receiver

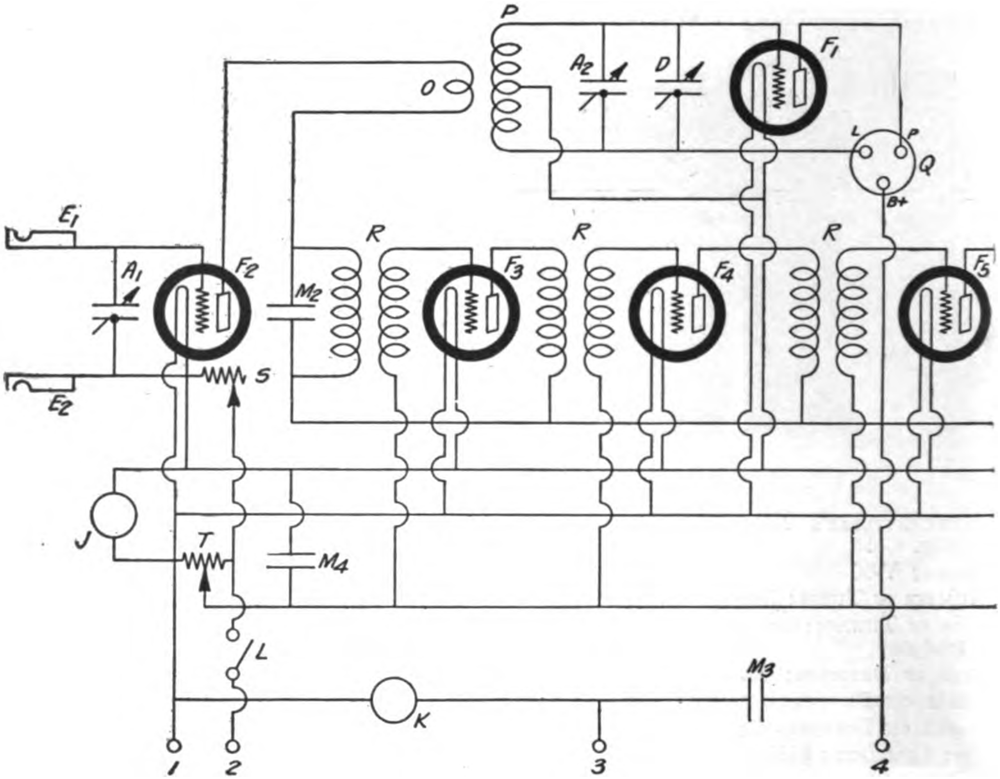
Manufacturer's Name; R. E. Thompson Mfg. Co.
Model; V-50
Number of Tubes; five
Type of Tuning; tuned-radio-frequency (neutrodyne)
Type of Detector; vacuum tube
Range on Phones; transcontinental
Range on Loudspeaker; transcontinental
Cost Complete; $125.00
Antenna Recommended; outdoor, 100 feet
Kind of Tubes for R. F.; UV-201-a
Detector Tube; UV-201-a
Audio Tubes; UV-201-a
Type of "A" Battery; 6-volt "A" battery
Type of "B" Battery; 90 to 100-volt dry or storage battery
Detector "B" Voltage; 22½ to 45 volts
Wavelength Range; 195 to 570 meters
Number of Tuning Controls; three
"A" Battery Current Used; 1.25 amperes
"B" Battery Current Used; 10 to 18 milliamperes according to "B" battery and "C" battery voltage used

---



The Elkay Super-selector

Manufacturer's Name; The Langbein-Kaufman Radio Co.
Model; Elkay Super-selector
Number of Tubes; four 201-a; four U-199; or any combination
Type of Tuning; tuned-radio-frequency
Type of Detector; vacuum tube
Range on Phones; 3,000 miles
Range on Loudspeaker; 2,500 miles
Cost Complete; $70.00
Antenna Recommended; 75 to 125 feet outside
Kind of Tubes for R. F.; 201-a
Detector Tube; 201-a; UV-199; sodion
Audio Tubes; 201-a; UV-199
Type of "A" Battery; 6 volts
Type of "B" Battery; 90 volts
Detector "B" Voltage; 22½ to 45 volts
Wavelength Range; 200 to 600 meters
Number of Tuning Controls; two
"A" Battery Current Used; maximum, 1 ampere
"B" Battery Current Used; 10 milliamperes



HOW TO BUILD THE NEW SUPERHETERODYNE WITH A

SINGLE CONTROL

The application of simplified tuning to various kinds of radio circuits for reception is one of the most important contributions that have been made to the radio art during the last year. The superheterodyne receiver here described is the most advanced of all the single-control developments that have as yet been made. This eight-tube set operates from a single dial as easily and satisfactorily as the simplest crystal receiver.

By JAMES L. McLAUGHLIN

COST OF PARTS: *Not more than $100.00*

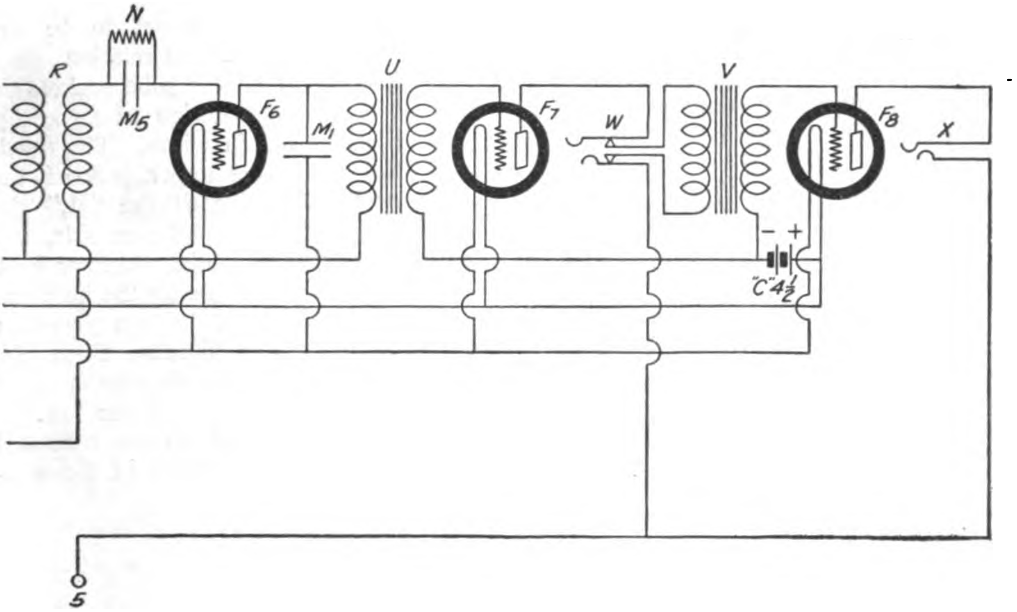
RECEIVING RANGE: *Up to 3,500 miles*

HERE ARE THE ITEMS YOU WILL NEED—

A1 and A2—Precise No. 750 syncrodensers, .0005 mfd.;
B—Precise No. 744 connector;
C—Marco 4-inch vernier dial, clockwise;
D—Hammarlund, Jr., midget condenser;
E1 and E2—Carter imp jacks (with plugs for loop wires);
F1, F2, F3, F4, F5, F6, F7, F8 and G—Benjamin No. 9050 8-gang socket-shelf;
H—bakelite panel, 10 inches by 14½ inches by 3/16 inch;
I1 and I2—Precise aluminum brackets No. 99;
J—Weston No. 301 voltmeter, 0 to 7 volts scale;
K—Weston No. 301 milliammeter, 0 to 25 milliamperes scale;
L—Benjamin battery switch;
M1—New York Coil mica fixed condenser,

THE COMPLETE CIRCUIT DIAGRAM

Figure 1: *This is the hook-up for the single control superheterodyne. All the symbols of the instruments bear designating letters which appear in the list of parts and throughout the text and illustrations.*



.006 mfd.;
M2—New York Coil mica fixed condenser, .00025 mfd.;
M3 and M4—Dubilier 1. mfd. by-pass condensers;
M5—Dubilier No. 640 mica fixed condenser, .00025 mfd. with grid-leak clips;
N—Daven grid-leak, 2 megohms;
O—stranded wire loop with braided covering for coupling oscillator to circuit;
P—Precision Inducto-coupler No. 260;
Q—Precise No. 1900 filtoformer;
R—Precise No. 1700 super-multiformer;
S—General Radio rheostat, type 214A 2 ohm, 2½ ampere;
T—General Radio potentiometer, type 214A 400 ohm;
U—Precise audio-frequency transformer No. 480 (5 to 1);
V—Precise audio-frequency transformer No. 480 (2½ to 1);
W—Carter double circuit "holdtite" jack;
X—Carter single circuit "holdtite" jack;
Y—cabinet.

IN this article on superheterodyne theory and construction, it is my purpose to describe a single-control superheterodyne that employs eight tubes.

This receiver combines some of the latest scientific developments and contains the best designed instruments and can be assembled easily by any one—even if he has never before built any kind of a set.

All the parts used in this receiver are standard, well-known parts that may be obtained from any dealer.

From an efficiency standpoint this receiver insures an unusually long life for the "B" batteries, as it draws only approximately 10 milliamperes for the total plate current. This results in very economical operation.

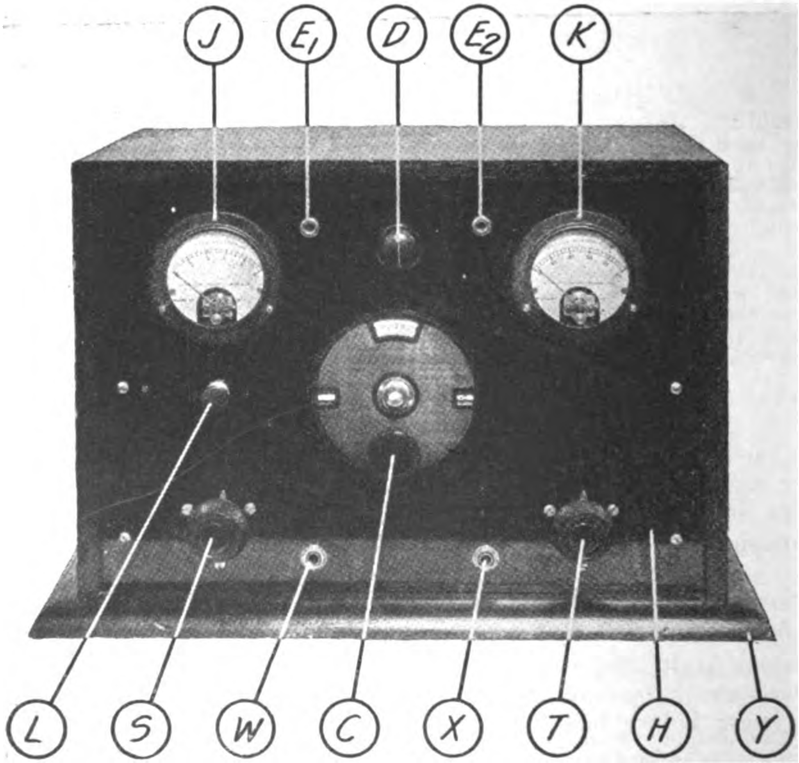
By the use of a combination of two straightline-frequency type condensers the application of single control has been advantageously applied to the superheterodyne receiver, as the difference in the frequency of the oscillator and the incoming signal is always a fixed value. In this design the oscillator and loop inductances are identical or as near alike as practicability will permit in regard to their inductance-capacity ratios.

The straightline variable condensers are placed across the loop and the oscillator for tuning, and a small midget variable condenser is also shunted across the oscillator condenser in order to make up for any small discrepancies there may be in either the coils, the condensers or the loop values. This allows the two condensers to be adjusted once and for all so that they operate synchronously.

The practice heretofore in multi-tube design has generally been to place all tube sockets in a row, making the resultant set a long, narrow, coffin-like affair when more than four tubes were employed. The reason for this elongated design was the necessity for keeping the output and input circuits of the unit as far apart as necessary to prevent reaction at radio or audio-frequencies. In this present receiver, after consideration and experiment, a unique design has been obtained in a system of tube placement which allows the set to be arranged in a more compact relation.

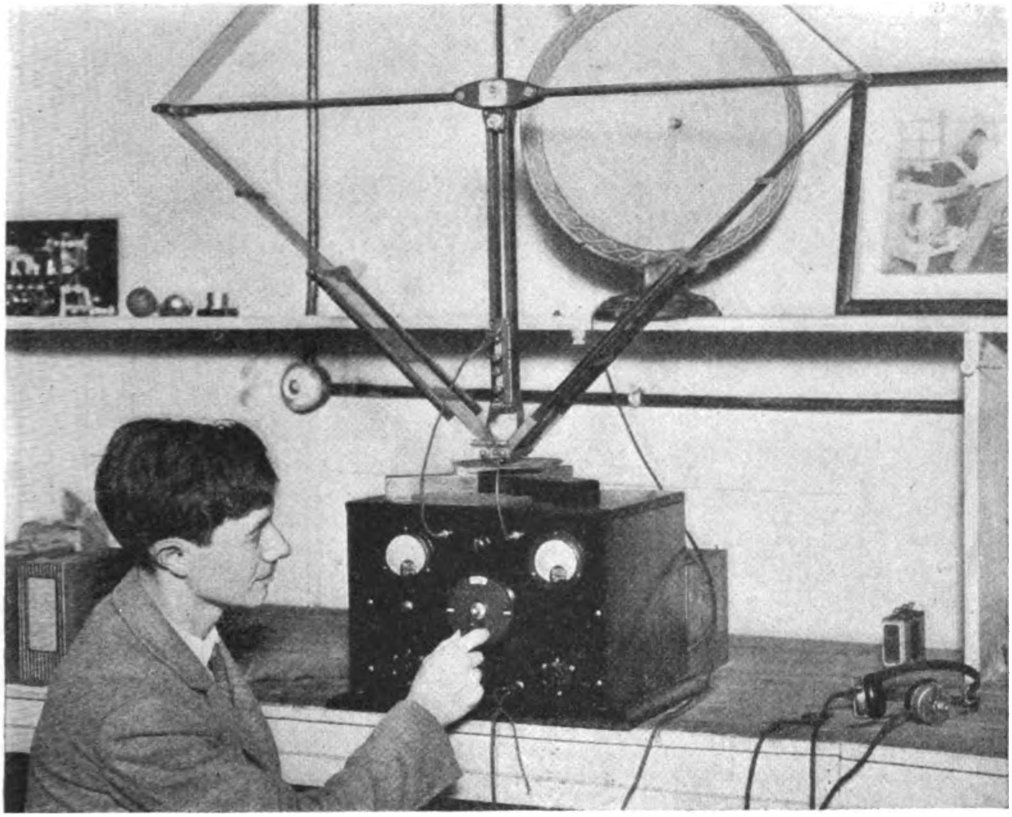
The placement of the tube sockets in this set follows the design of an exaggerated letter "H" in width. The oscillator tube forms the upper part of the left-hand vertical side of the "H," the first detector forms the lower side, the three radio-frequency tubes together with the second detector make up the horizontal connecting bar and the two stages of audio-frequency amplification form the right-hand vertical side, thus completing the other two legs of the letter "H."

The variable condensers are mounted in approximately the center of the sub-



HOW THE SET LOOKS FROM THE FRONT

Figure 2: *The vernier dial C is the single control for the two tuning condensers, while all other knobs are marked with the same letters as the instruments to which they are attached.*



From a photograph made for POPULAR RADIO

A SINGLE DIAL FOR TUNING A SUPERHETERODYNE

The author demonstrates the almost unbelievable simplicity for tuning a multi-tube set such as shown in this picture. This is the only control that is necessary—aside from the turning of the loop in the proper position to pick up signals.

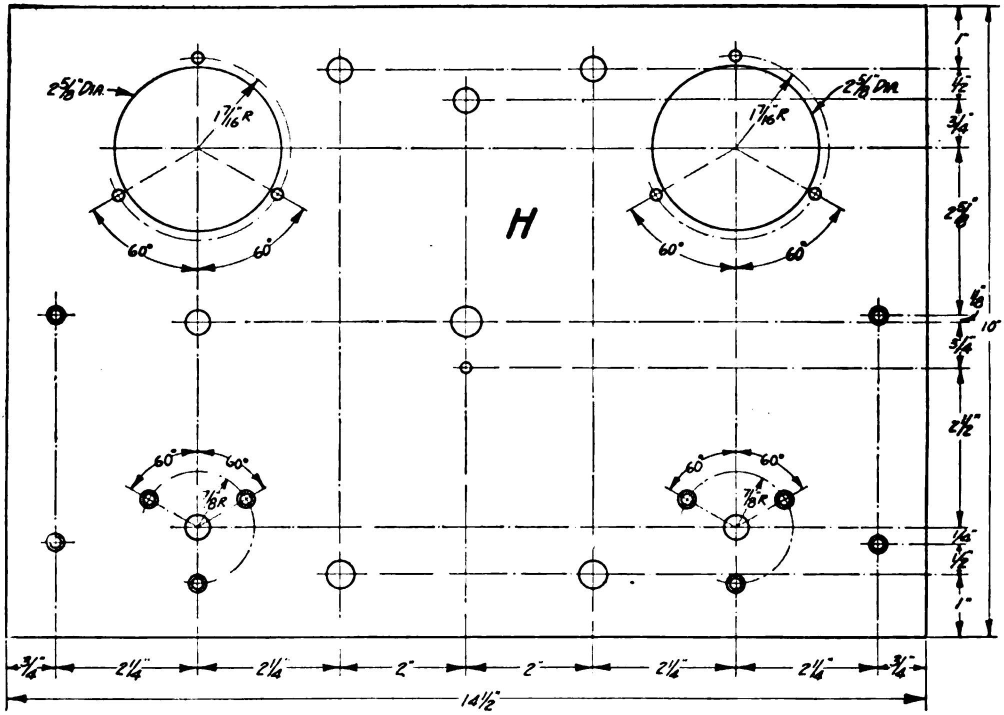
panel and are connected by means of a fiber connector which is attached to the shafts by means of set screws. This results in short connections to all the sockets, as the oscillator condenser is directly alongside of the oscillator tube and the tuning condenser is alongside of the first detector. On the underside of the subpanel are the intermediate gang-transformer, the audio-frequency transformers and the oscillator coil, fixed condensers and other parts. I have chosen for the intermediate gang-transformer the super-multiformer, a high-wave radio-frequency unit, as it is easy to connect into a circuit in one unit and operates on what is the most feasible intermediate frequency.

In the comparison of efficiency resulting from this arrangement and the use of the correct values as described in this article we have proved conclusively that there is no operating disadvantage at all in making this receiver so compact although the small shape and general design make it a much better looking set.

In operation the receiver produces very fine quality, is decidedly selective and may be operated over a range in excess of 3,500 miles, covering the whole broadcast range of wavelengths.

Parts Used in Building the Set

In all the diagrams in this article each part bears a designating letter; in this way, the prospective builder of a set may easily determine how to mount the instruments in the cor-



THE DRILLING PLAN FOR THE PANEL

FIGURE 3: *This drawing shows where to drill the holes for mounting the instruments. The large holes for mounting the meters should be cut with a special adjustable fly cutter for bakelite. Holes outlined with a double circle should be countersunk.*

rect places and connect them properly in the electric circuit.

The same designating letters are used in the text and in the list of parts at the beginning of the article.

¶ *The list of parts there given includes the exact instruments used in the set from which these specifications were made up. The experienced amateur, however, will be able to pick out other reliable makes of instruments which may be used with equally good results. But we recommend that the novice follow the list, as the diagrams in this article will tell him exactly where to bore the holes and exactly where to place the connections.*

If instruments other than the ones listed are used, the only change that will be necessary will be the use of different spacings for the holes that are to be drilled in the panel for mounting the instruments.

How to Construct the Set

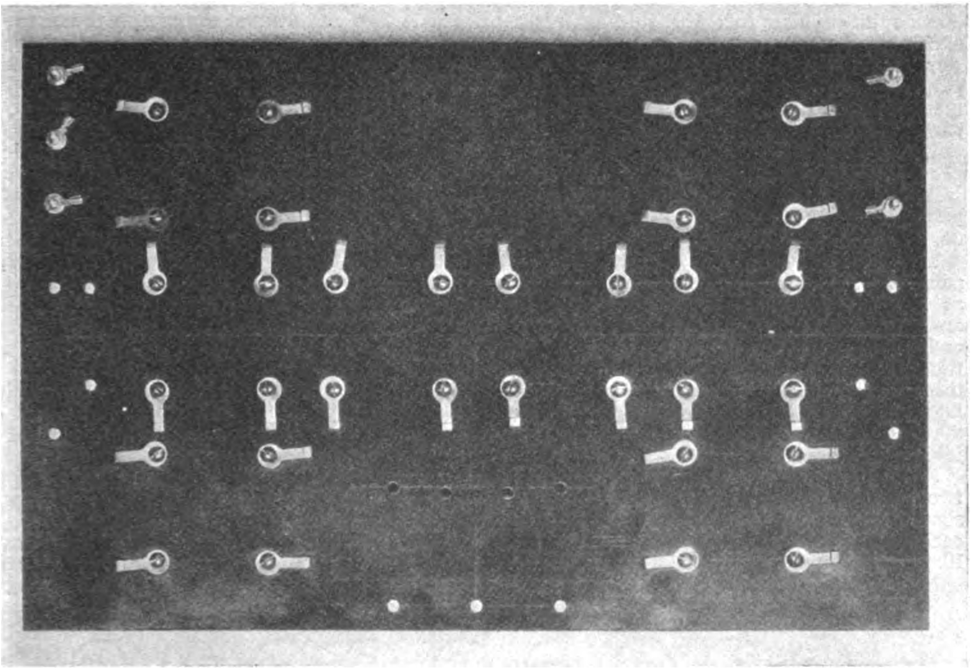
After procuring all the instruments and materials for building the set, the amateur should prepare the panel H. (Shown in Figures 2, 3, 6, 7, 8 and 10.)

First of all, cut the panel to the correct size, 10 by 14 inches. Then square up the edges smoothly with a file. The centers for boring the holes (which are necessary for mounting the instruments) should be laid out on the panel as shown in Figure 3. A convenient method for doing this is to lay out all center holes on a piece of paper the same size as the panel; then the piece of paper may be fastened on the panel and the centers marked directly on the panel by punching through the paper with a sharp, pointed instrument.

If all the holes to be drilled are first started with a small drill, one-sixteenth inch in diameter or less, they can be more nearly centered.

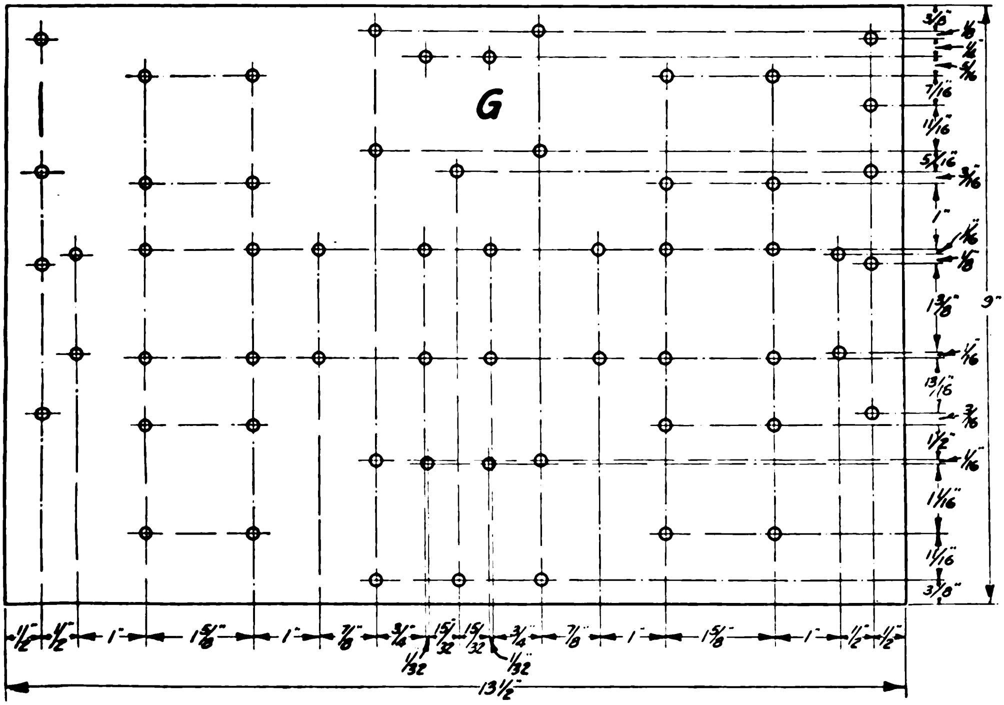
The holes outlined with a double circle should be countersunk, so that the flat-head machine screws used for fastening the instruments are flush with the panel. All the rest of the holes in the panel are straight drill-holes. Sizes for the diameters of these holes have not been given, but the builder will readily decide what size hole is necessary by measuring the diameter of the screws and shafts of the instruments that must go through the holes.

When the panel is drilled, the builder may give it a dull finish by rubbing the face of the



THE SUB-PANEL FROM BELOW

FIGURE 4: *This picture shows how the lugs and screws that connect to and mount the sockets are arranged on the bottom of the sub-panel.*



THE DRILLING PLAN FOR THE SUB-PANEL

FIGURE 5: *Where to drill the holes for mounting the various instruments.*

panel lengthwise with fine sandpaper until it is smooth. This process should be repeated, except that light machine oil should be applied during the second rubbing. Then rub the panel dry with a piece of cheesecloth. A permanent dull finish will be the result. Or, the panel may be left with its original shiny-black finish, if care has been exercised, so that it has not been scratched during the drilling.

After the panel has been prepared the experimenter is ready to mount the instruments on it.

The rheostat S should be attached to the panel by screws inserted in the proper places as shown in the diagrams in Figures 2, 7, 8 and 9. Do the same with the potentiometer T, and be sure that the terminals are turned in the correct position as shown for both of these instruments in Figure 8. Place soldering lugs underneath every connection for making the wiring easier and insuring a more efficient job.

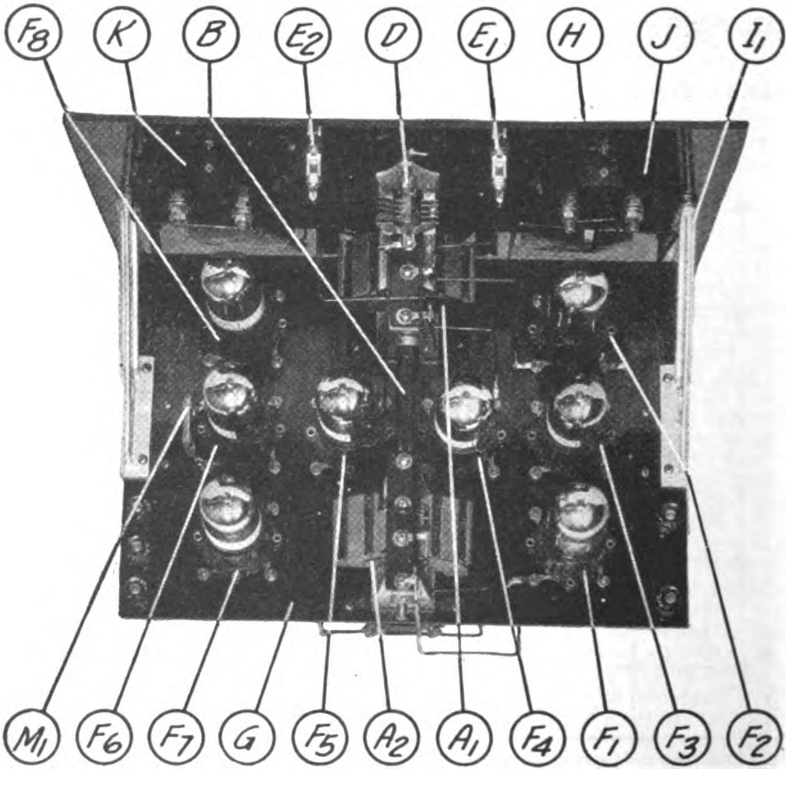
Next, mount the two meters J and K in the two holes cut for them in the panel. This should be attached by three nuts and bolts for each instrument as shown in Figures 2, 6 and 10.

Next attach the midget condenser D in the proper place on the panel as indicated in Figures 2, 6 and 10 and tighten up the single-hole mounting nut firmly. Also mount the battery switch L and the two large jacks W and X and the small loop-jacks E1 and E2 in their proper places as shown in Figures 2, 6, 7, 8, 9 and 10

This completes the mounting of instruments on the main panel H. Now turn to the work on the sub-panel or socket-shelf G. If the builder wishes he can procure this already drilled with the sockets mounted upon it as indicated in the list of parts under F1, F2, F3, F4, F5, F6, F7, F8 and G.

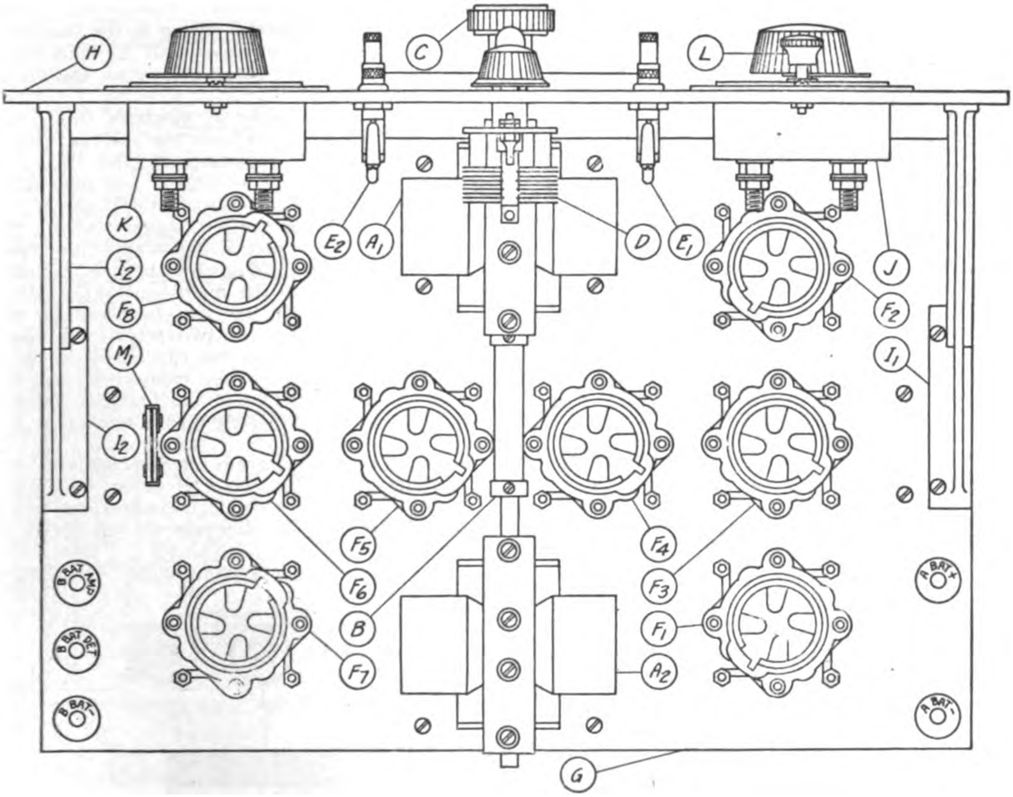
However, if he decides to make it himself he may procure the bakelite according to the size shown in Figures 4 and 5 and drill it according to the dimensions given there and after procuring the eight sockets they should be mounted (minus the separate bases that come on them) as shown in Figures 6, 7, 10 and 11.

Whether the complete assembly has been bought or whether you have drilled the panel and mounted the sockets yourself, you are now ready to mount the rest of the apparatus. The two variable condensers A1 and A2 are mounted directly in the center of the top side of the panel G. They should be connected together



VIEW OF THE SET FROM ABOVE

FIGURE 6: *Note the general arrangement of the two synchronously controlled condensers, the sockets and the meters when viewed from above with the cabinet removed; also the similarity of the socket mounting to the letter H.*



THE WORKING DRAWING FOR CONSTRUCTION

FIGURE 7: *Here are shown the correct positions for the instruments that are mounted on the panel and on the top of the sub-panel. The positions are shown clearly as they actually are in the receiver.*

with the coupling-unit B, as shown in Figures 6, 7 and 11.

When these have been installed attach the intermediate-gang transformer (super-multiformer) as shown in Figures 8 and 9 by inserting screws through the places indicated at the two ends and fastening with nuts.

Next mount the two transformers U and V—being sure that you place the proper "ratios" in the right places as indicated in Figures 8, 9, 10 and 11. Also be sure that they are turned with the terminals in the correct position as shown in Figure 9.

Next mount the inducto-coupler in the proper position as shown in Figures 8, 9 and 10, utilizing the same screw terminals to replace the screws to mount half of the socket F1. Then fasten the filtoformer Q in proper position at right angles to the inducto-coupler with the terminal marked P next to the sub-panel and the terminals marked B and L pointing away from the panel. See Figures 8 and 9 for this data.

Next, mount the grid condenser M5 (in the terminals of which place the grid-leak) on the last binding post marked G of the super-multiformer. This is clearly indicated in Figures 8 and 9. On the first terminal marked B of the multiformer mount the fixed condenser M2 as shown in Figures 8 and 9. Also mount the fixed condenser M on the two terminals of the second detector socket as shown in Figures 6 and 7.

Another job that can now be done is to attach the two brackets I1 and I2 with two screws and bolts as shown in the various Figures. The last job to do is to mount the two bypass condensers M3 and M4 with a single point of support under the screws as shown in Figure 9. This finishes the construction work on the sub-base and the two panels are ready to be wired up and placed together.

How to Wire the Set

The design of this set is such that the wiring of the grid circuit of each of the four tubes is made extremely short and is isolated from other parts of the circuit. In fact, this idea has been employed throughout and the leads are so arranged that the shortest connections may be used. As this is the case, the set should be wired with bus-bar.

A tinned-copper, round bus wire is recommended. All connections should first be shaped so that they will fit. They should then be soldered in place. Refer to the wiring diagram in Figure 1 and more specifically to the picture diagram in Figure 12 for the exact way in which to run the wires.

Start wiring by making all the connections on the sub-panel first on the bottom side then on the top side that can be done without attaching the sub-panel to the main panel, by means of the brackets I1 and I2. If you follow the picture-wiring diagram in Figure 12 for making these connections you cannot go wrong. This drawing shows every instrument mounted on either the top or below the sub-panel G as included in the lower rectangle. The instruments outlined here in solid black lines show only those instruments that are mounted on top of the panel, whereas the instruments outlined in dotted lines show those that are mounted below the sub-panel.

Also the heavy black lines shown in Figure 12 indicate the wiring connections for the wires that run above the panel and the wires that run below the panel are shown in dotted lines.

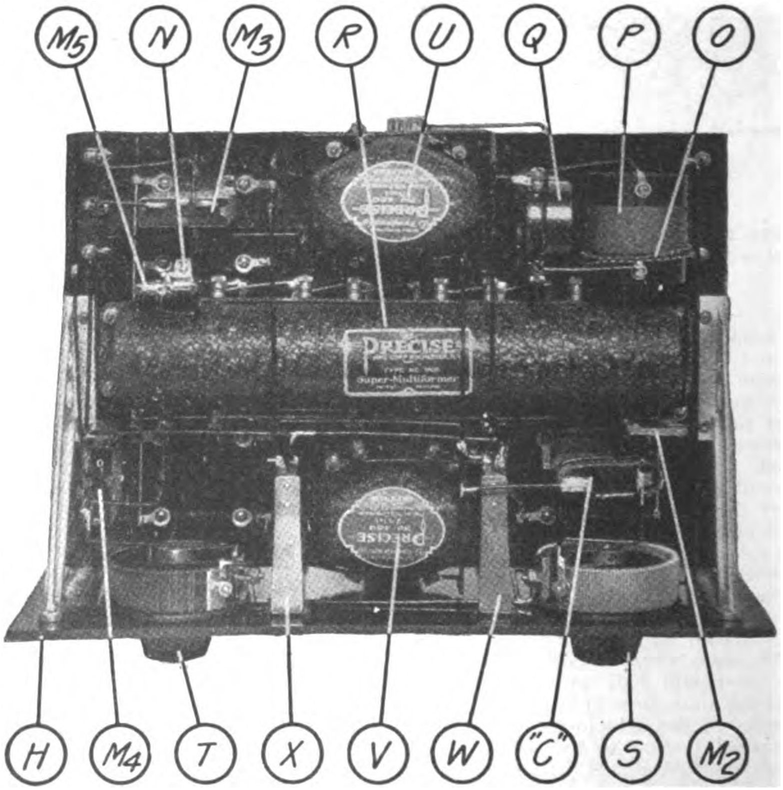
It is best to begin wiring with the filament circuits underneath the panel and finish all connections that can be made in inaccessible places first. Then finish up the wiring to the two condensers on top of the panel with the leads running to the proper place below, as shown in Figure 12.

When you have done as much of this work as is possible, and you have the sockets, transformers, coupler, binding posts and the condensers all connected as shown, you may start on the wiring of the main panel H.

There is one connection between two of the terminals of the potentiometer and the rheostats which should be finished before the sub-panel is attached to the main panel H. When this is done attach the two brackets to the main panel by means of two screws and nuts to each bracket. Then you can finish the wiring incorporating in it the connections to the jacks and the meters and the filament battery switch as well as finishing up the wiring to the rheostats.

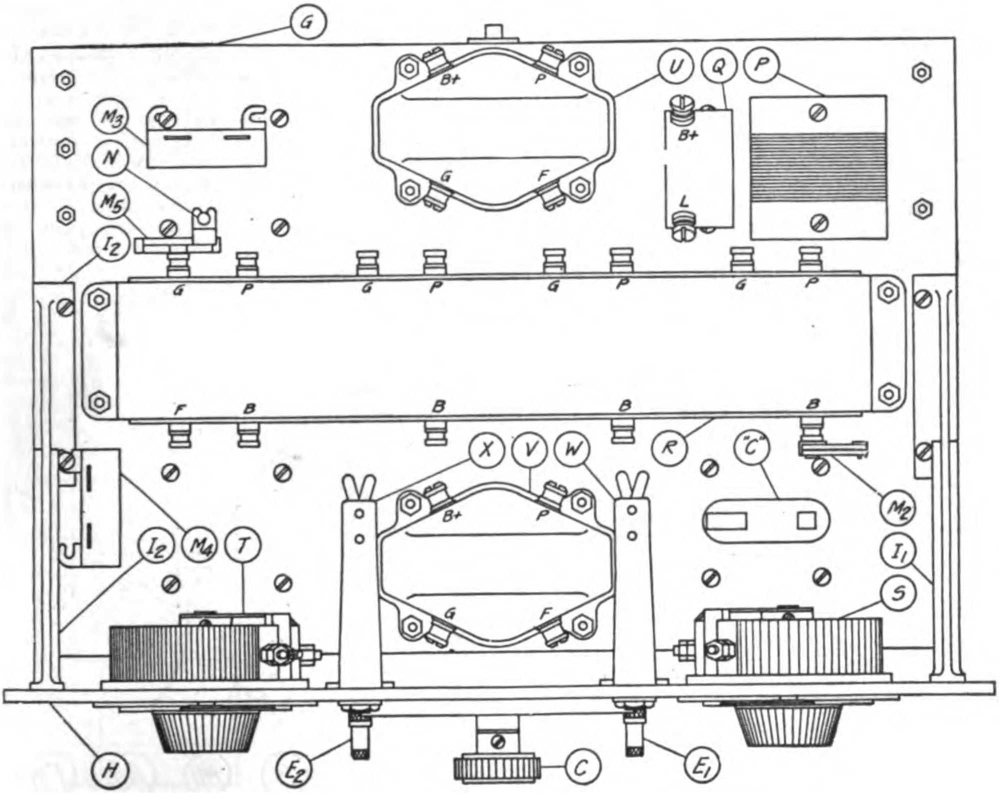
The schematic diagram that shows you the circuit used in this receiver is shown in Figure 1, but in making electrical connections it is easier to follow the diagram as set forth in Figure 12.

If you make every connection exactly as



VIEW OF THE SET FROM BELOW

FIGURE 8: *Note how the transformers, rheostats, bypass condensers, inducto-coupler, filtoformer and the jacks are mounted in compact assembly below the sub-panel. All the parts are accompanied by designating letters which re-appear in the text and in the list of parts.*



ANOTHER CONSTRUCTIONAL WORKING DRAWING

FIGURE 9: *This drawing shows the exact arrangement of the various parts that are mounted below the sub-panel. Notice that the various terminals of the transformers are marked with the same letters that appear on the transformers; this will enable you to place them without any chance of error.*

shown you will have no trouble in getting the set to work properly. It is advisable to use for this purpose some kind of insulated bus-bar. The wiring of the experimental set was done with Celatsite. Connect the wiring wherever possible to soldering lugs and use only enough solder and flux to make a good electrical connection, wiping each joint dry after it has been made. The No. 751 Eveready "C" battery shown on the diagram at "C" may be supported by the wiring or it may be held with a small brass bracket, if preferable.

In doing your wiring job remember that care and neatness will enable you to do a correct and efficient job. Don't hurry. Take it easy and check over your wiring as many times as necessary to be sure that you have done exactly the right thing as shown in the picture diagram in Figure 12.

All the instruments are marked with designating letters and the important binding-post terminals on the transformers and coils are marked with designating letters for your information.

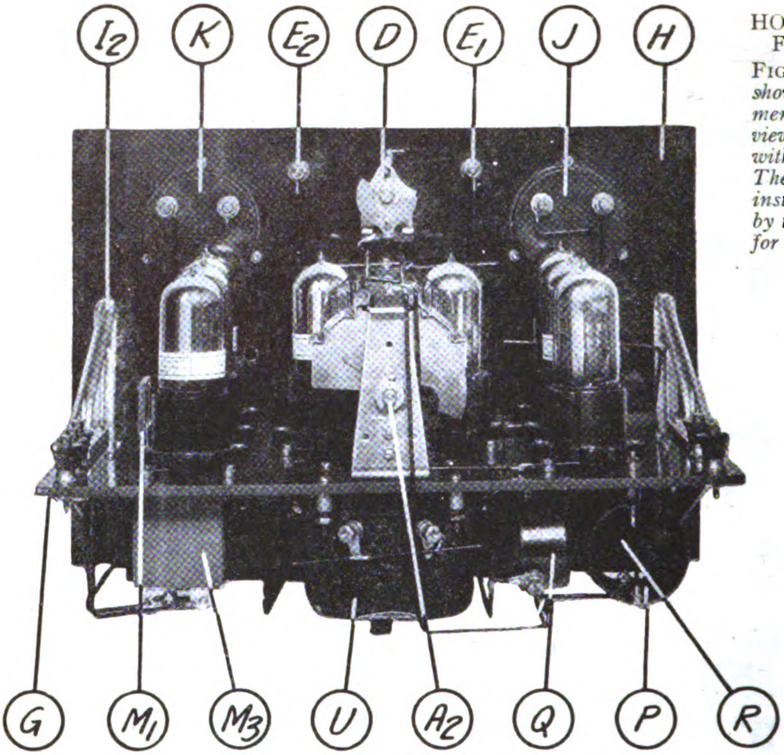
It will be noticed that the loop terminals are brought out to the small Imp jacks E1 and E2.

How to Install the Set

After the wiring has been completed the large dial C should be attached to the condenser shaft that protrudes through the face of the main panel H. Instructions for mounting this dial will be found in the small folder that comes with the dial. This leaves the set ready to be installed in the cabinet; the details of which are given in Figure 14, which shows all the mechanical dimensions for the cabinet. One of these may be obtained from a cabinet manufacturer or you may take the dimensions to a neighboring carpenter who can build it from the diagram. Slide the panel down into the cabinet with the lid open. You will notice that there are two grooves that hold the panel in a vertical position. This is all that is necessary as a support for the receiving set.

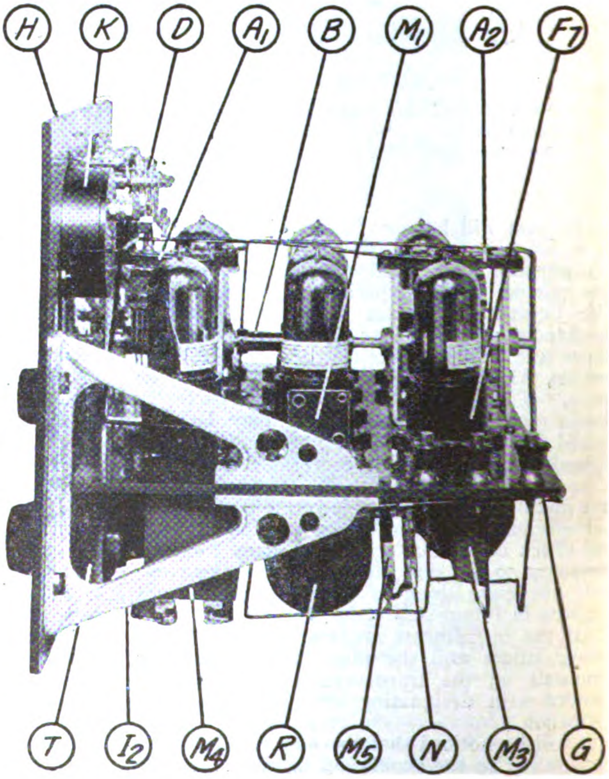
Next insert the eight standard tubes in the sockets—first being sure that the battery switch L is pushed all the way in on the "off" position. I have used the Brightson tubes in this set with fine results, although any standard make of tube can be used.

Then connect up the two 45-volt "B" bat-



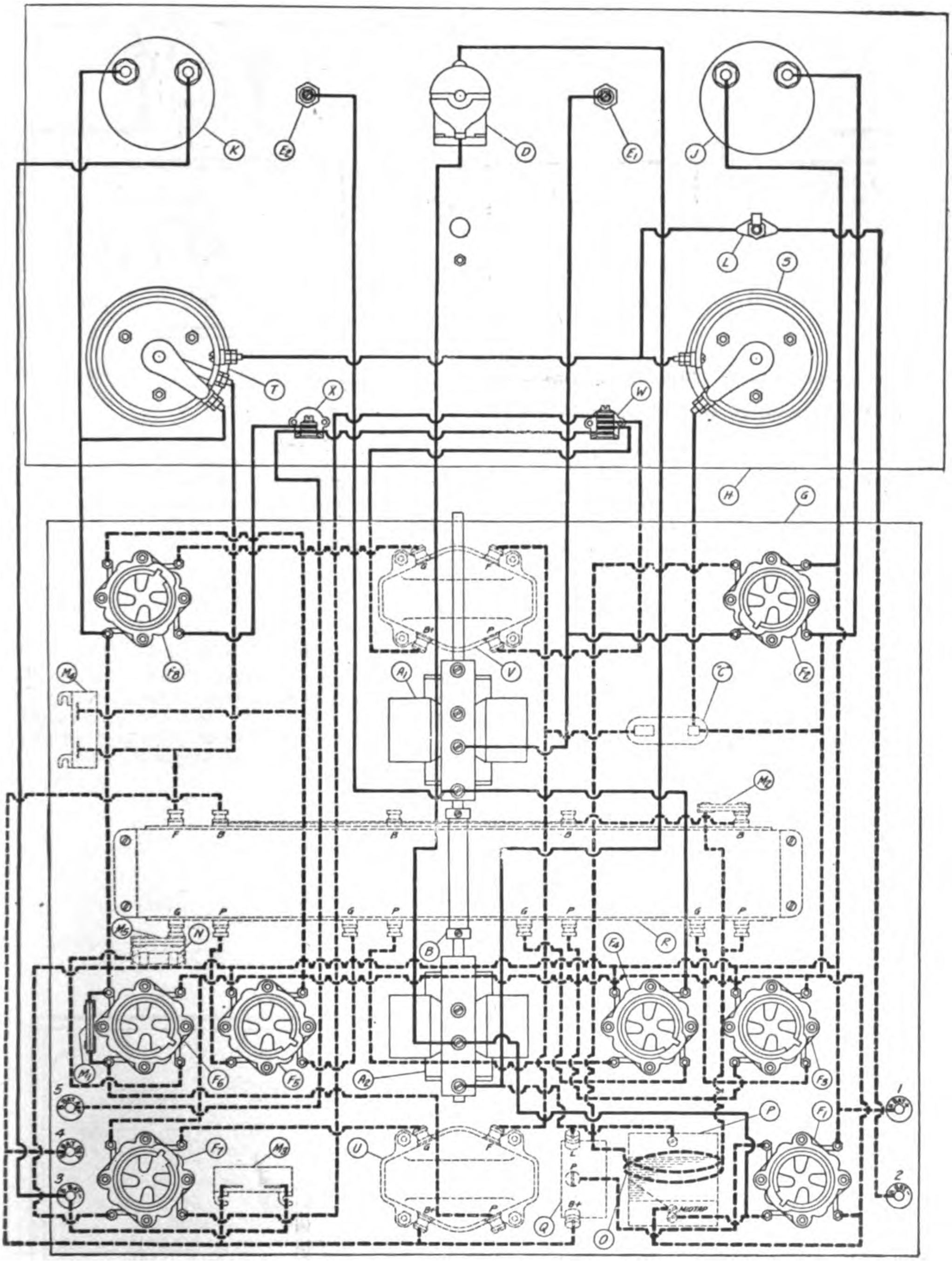
HOW THE SET LOOKS FROM THE REAR

FIGURE 10: *This picture shows the general arrangement of the instruments as viewed from the rear and with the cabinet removed. The exact positions for the instruments are determined by the screw holes, the data for which are given in Figures 3 and 5.*



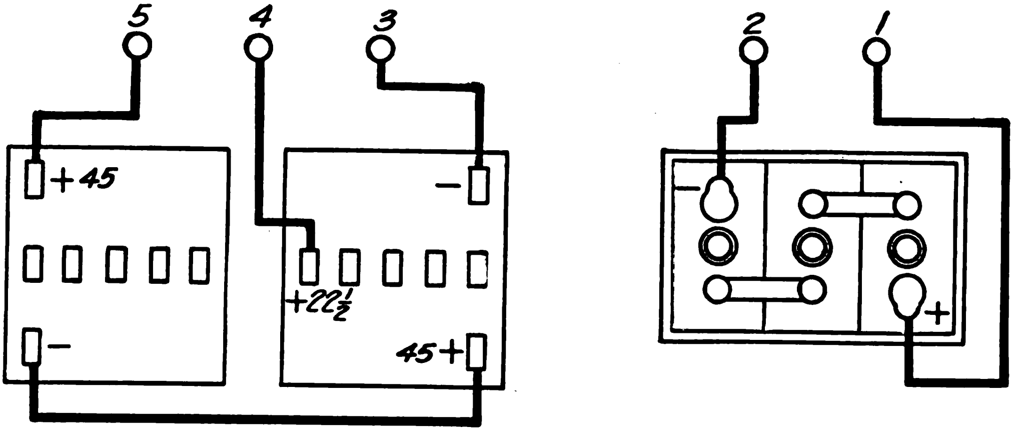
VIEW OF THE SET FROM THE RIGHT

FIGURE 11: *This end view indicates the manner of mounting the sub-panel by means of the large brackets; it also shows the arrangement of the sockets, transformers, bypass condensers, meters and the binding posts.*



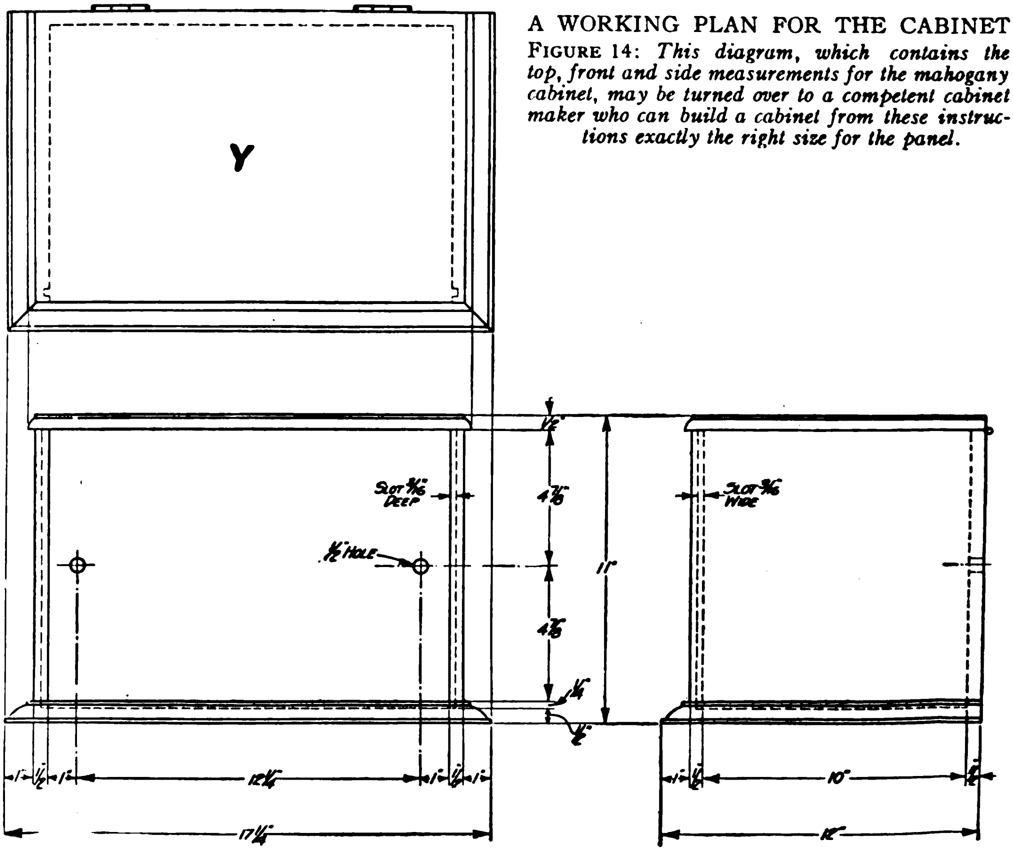
THE WORKING PLAN FOR CONNECTING UP THE INSTRUMENTS

Figure 12: *The upper rectangle represents the main panel and on it the instruments are drawn as they appear as viewed from the rear; the lower rectangle represents the sub-panel. The instruments are represented in about their relative position. Those instruments indicated in this diagram in heavy black lines are mounted on* Top *of the sub-panel and those in dotted lines are mounted* Below *the panels. Likewise the wiring that is shown in heavy continuous lines should be done on top of the sub-panel and the wiring shown in dotted lines should be completed underneath the sub-panel.*



HOW TO CONNECT THE BATTERIES

FIGURE 13: *This drawing will prevent you from making mistakes in connecting the batteries to the terminals at the back of the receivers. If you follow these instructions the set will be hooked up correctly, as the terminals shown in the wiring diagram are marked with the same numbers that are given here.*



A WORKING PLAN FOR THE CABINET

FIGURE 14: *This diagram, which contains the top, front and side measurements for the mahogany cabinet, may be turned over to a competent cabinet maker who can build a cabinet from these instructions exactly the right size for the panel.*

teries as indicated in the diagram in Figure 13. Also connect the 6-volt "A" battery in the manner indicated in the battery hook-up in Figure 13.

Then set the "DTW" loop on top of the set as shown in the illustration on page 353, in which the author is shown tuning the receiver. The receiver is designed especially to be used with this large German loop, which is an extremely efficient piece of apparatus and contains just the correct value of inductance when the two wires leading from the plugs and jacks E1 and E2 are connected to the top and bottom terminals on the loop. Use two short flexible pieces of wire in making this connection.

How to Operate the Receiver

The next procedure is to place the head telephones in jack W or the loudspeaker in jack X prior to operating the receiver. Then with the rheostat S turned over and to the left in an anti-clockwise direction pull out the battery switch L and adjust the rheostat S by turning in a clockwise direction (over to the right) until the voltmeter J reads approximately 4½ volts. Then adjust the potentiometer knob T until a reading of approximately 10 milliamperes is obtained on the milliammeter K. These are practically the final adjustments for the potentiometer and the rheostat.

Then revolve the dial C by means of the small knob until a station has been picked up. Tune it in as loud as possible and leave this dial fixed. Then with a slow motion of the small knob D, adjust the vernier condenser until the oscillator and loop circuits are in perfect synchronism. This will bring up the signal to its greatest strength, and when this is once done the knob D can be left fixed.

For tuning in any other stations after this nothing is necessary to do but revolve the white sectored dial C by means of the small knob located on the round black disc.

Stations that are tuned in between zero and 50 on this dial may be logged by writing in the call letters in the small white rectangular aperture at the left side of the dial with a pencil. Stations that tune in above 50 on the dial should be written in on the small white rectangular aperture on the right-hand side of the dial.

To re-tune stations all that is necessary is to rotate this dial C until the correct call letters of the stations that you want to hear appear in these two apertures.

Of course, for best operation the loop should be turned so that its plane is in line with the station you want to hear.

On distant stations it may be necessary to slightly adjust the potentiometer T to the right or to the left in order to bring the signal in with great intensity. This will cause the milliammeter K to vary slightly above or below the 10 milliammeter mark. The voltmeter, however, should always read 4½ volts and the rheostat S adjusted only when the battery voltage changes, thus making an adjustment of the rheostat necessary. *Watch your meters for best operation.*

To turn off the set all that is necessary is to push in the battery switch L which completely opens the filament circuit.

If all the instructions that have been given in this article are followed minutely, even a beginner can build this set and obtain very fine and enjoyable results from it both on local and distant reception. The receiver tunes as sharp as a hair.

International

TAPPING THE BRAINS OF THE AMATEURS

In order to take advantage of the ideas of ingenious young radio experimenters, Mr. Edward H. Jewett of Detroit, Michigan, recently invited radio amateurs to come into the laboratory of his million-dollar factory and submit ideas. Three of the amateurs of the hundreds who applied were turned loose in the laboratory—and between them they worked out a device which has come to be one of the chief products of the factory.

Conducted by Hugh S. Knowles

In justice to our regular subscribers a nominal fee of fifty cents per question is charged to non-subscribers to cover the cost of this service, and this sum must be inclosed with the letter of inquiry. Subscribers' inquiries should be limited to one question or one subject.

An Inductive Coupled Transmitter

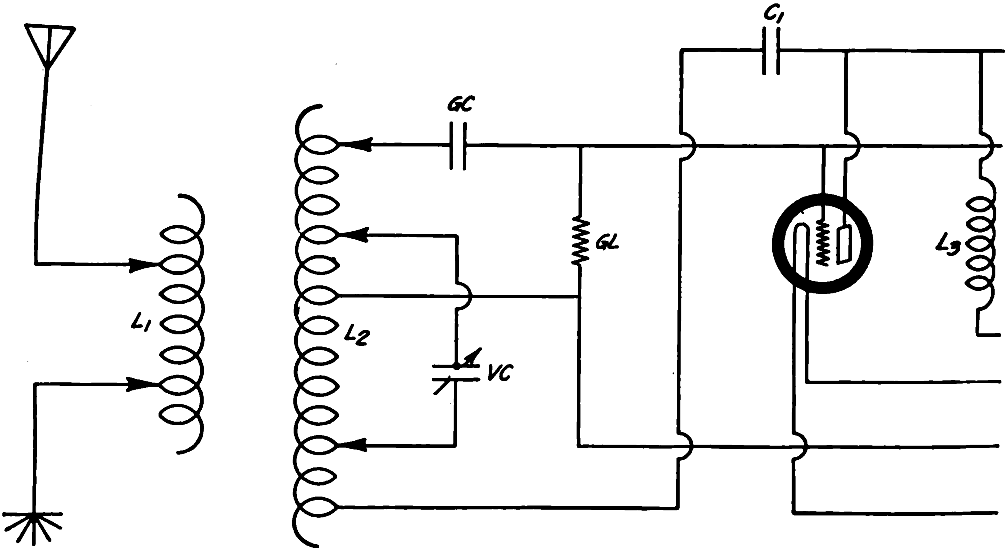
Question: I have a transmitter that uses two five-watt tubes in parallel in a conductively coupled Hartley circuit with 60 cycle A.C. on the plates. I should like to change this transmitter to conform with the new regulations requiring inductive coupling and full wave rectification. I want to operate it on the eighty meter band.

Dick Binnin

Answer: In Figure 1 you will find a diagram of a transmitter of the type you require. You will need the following parts:

L1 and L2—secondary and primary of an O. T. (oscillation transformer);
VC.—.00025 double spaced variable condenser.
GC, C1 and C2—.002 mica transmitting condenser;
L3 and L4—radio-frequency chokes;
C3 and C4—.002 low voltage condensers;
T1—plate supply transformer giving 550 volts on each side of the mid-tap and having a capacity of 50 or more watts;
T2—filament supply transformer (8-9 volt, 50 watt);
R—primary rheostat;
GL—5,000-10,000 ohm grid-leak.

L2 can be made by winding 12 turns of number 8 or 10 bare copper wire on a skeleton frame 5 inches in diameter with the turns spaced the diameter of the wire. L1 should be made on the same type of frame and 6 turns should be used. It should be mounted



so its coupling to L2 can be readily changed.

In changing over from the conductively to the inductively coupled type of transmitter it must be borne in mind that the closed circuit comprising the grid and plate coil variable condenser and input to the tube has to carry as much as fifteen times the current it carries when conductively coupled to the antenna. To minimize the losses in this circuit the inductance should be designed to carry the heavier current and the condenser should be a low-loss double spaced or transmitting type such as the Cardwell transmitting.

L3 and L4 should be made by winding 150 turns of No. 30 D.C.C. wire on a 3-inch tube.

The circuit given is for a separate filament transformer. This arrangement is advisable as it allows close control of the filament voltage without the use of a rheostat directly in the filament circuit which would upset the balance obtained by the use of the mid-tap. The rheostat R should be one similar to the new E 210 Bradley.

If the fundamental of the antenna circuit is above 80 meters insert a variable condenser in the counterpoise or ground lead. Loose coupling between L1 and L2 will minimize interference to broadcast receivers, make the transmitter stable and the note better. Test with a receiving station as the maximum deflection point on the antenna meter may not be the best place to operate.

"C" Battery for Neutrodyne Receiver

QUESTION: I have a homemade five-tube neutrodyne receiver with which I use three large-size, 45-volt "B" batteries. It seems to me that the "B" batteries have to be replaced altogether too frequently, and I wonder if there is some way in which I can prolong the life of these batteries without interfering with the good results I am now getting so far as volume and distance are concerned. Can you advise me? I might add that I have been thinking of installing a "C" battery, but do not know whether this would help.

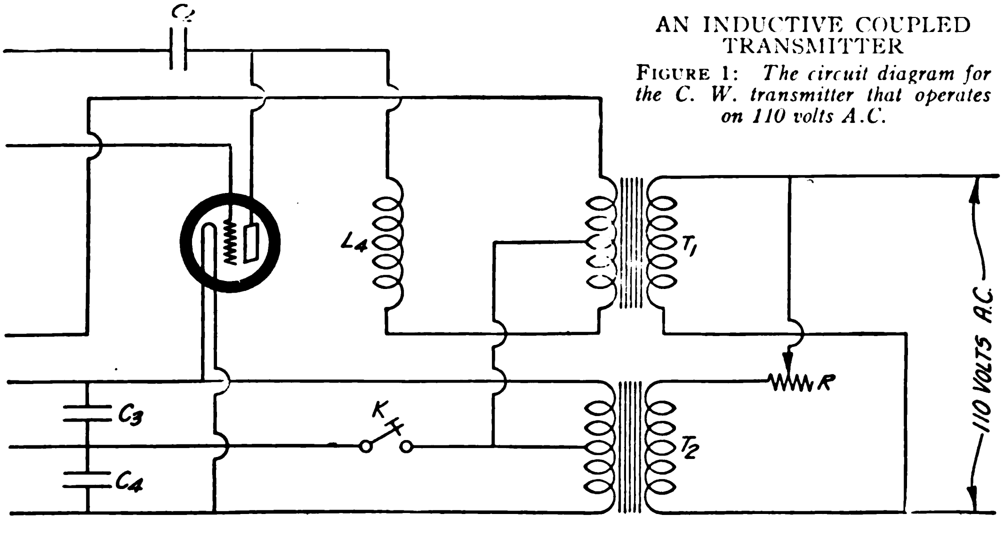
BEN WEBSTER

ANSWER: By all means install the "C" battery in the grid returns of the audio-frequency amplifier tubes. This should make the "B" batteries last at least 25 percent longer. Next try using only two of the 45-volt batteries instead of three. This will undoubtedly improve the tone quality of the receiver, will give only slightly less volume than you now obtain, and will lengthen the life of your batteries materially. Finally, use the "oversize" 45-volt batteries, such as the Eveready No. 770 type. The first cost of these larger batteries is somewhat higher than the batteries you now use, but their life is almost twice as great. By following out these suggestions the life of your "B" batteries should be several hundred percent greater than at present. It is highly probable, too, that tone quality will be improved and volume equal to that obtained at present.

Static on Various Wavelengths

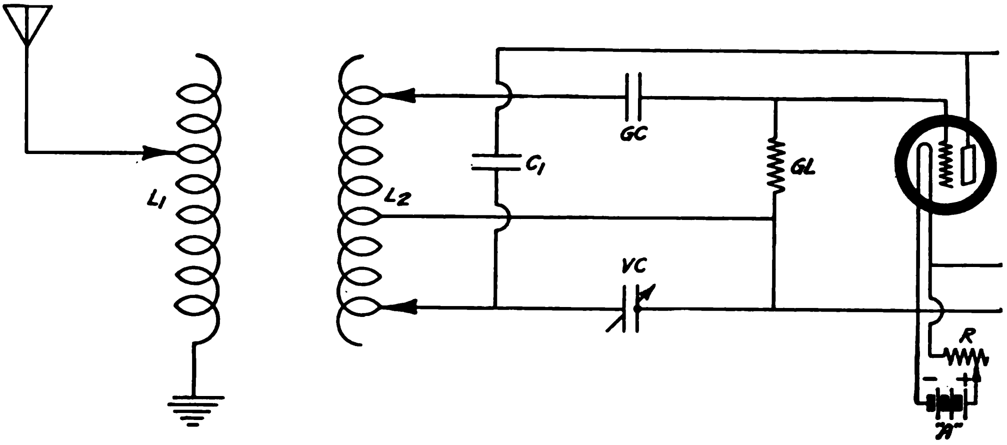
QUESTION: Is it true that the static that is heard on the broadcasting waves of 300 to 500 meters is absent on short waves of 40 to 80 meters?

ALEXANDER SMYTHE



AN INDUCTIVE COUPLED TRANSMITTER

FIGURE 1: *The circuit diagram for the C. W. transmitter that operates on 110 volts A.C.*



A LOW POWER TRANSMITTER FOR TELEPHONY

Figure 2: *This diagram shows how the various instruments in the circuit should be connected for a simple transmitter employing Heising modulation.*

Answer: Yes, sometimes this is the case although by no means a rule. Static is no respecter of wavelengths and is sometimes prevalent over a considerable band. As an instance, static conditions may prevail on 40 meters, be considerably less on 80 meters and again very loud on 250 meters.

A Low Power Phone Transmitter

Question: I should like to experiment with a small telephone transmitter which would be capable of transmitting a couple of miles. If possible I should like to operate it on a storage battery and regular B batteries. Will I need any license to operate a low power transmitter of this type?

Howard Bean

Answer: In Figure 2 you will find a diagram of a low power phone transmitter. You will need the following parts:

L1 and L2—secondary and primary of coupler;
C1—.002 condenser which will stand the B voltage;
VC—.00025 variable condenser;
GC—.0005 condenser;
GL—variable grid-leak;
L3—radio-frequency choke;
L4—audio-frequency choke;
M—microphone;
MT—modulation transformer;
R—filament rheostat.

L2 should be made by winding 36 turns of number 18 D.C.C. on a 4-inch tube and tapping it in the middle. L1 should have about 20 turns of the same size. This should be mounted so the coupling to L2 can be varied. If the fundamental of the antenna is below the wave you wish to work on L1 can be tapped every two turns and adjusted until the maximum power is emitted. If it is above this value you will have to insert a variable condenser in the ground lead.

L3 can be made by winding 200 turns of number 32-36 D.C.C. on a 3-inch coil.

Any good audio choke or the secondary of an audio transformer designed to carry a fairly high current can be used for L4.

Any good amplifier or power tube can be used in this circuit. If 201-a tubes are used B should not be over 150 volts. Better results can be gotten by using VT2s (Western Electric) or a power tube which will operate on a storage battery. Up to 350 volts can be used on the latter permitting transmission over a greater range.

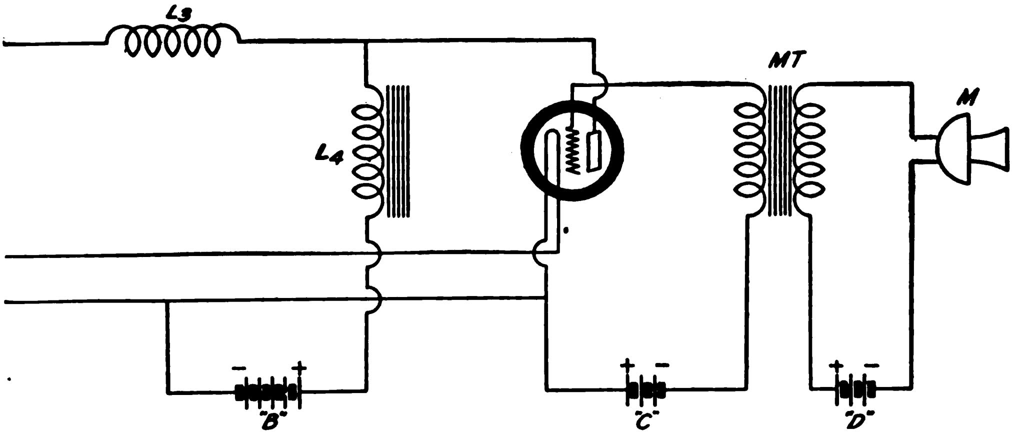
The voltage of C will vary from about 6 to 30 volts, depending on the tube and plate voltage.

D is the microphone battery, and its voltage is determined by that necessary for the "mike."

Regardless of how little power is used both a station and operator's license must be obtained before you do any transmitting. The latter means that the code must be learned even if you are to use only a phone transmitter. Communicate with the radio inspector in your district for blanks and particulars on how to obtain a license.

Sub-panel Instrument Mounting

Question: I want to fasten some transformers under a ¼ inch thick bakelite sub-panel. Is it possible to drill and



tap holes without drilling clean through the bakelite?

TOBIAS S. NORTON

ANSWER: This is quite possible but requires much care. For 6/32 screws use a No. 31 drill, and while drilling stop frequently to plumb depth of hole. Drill the hole only 3/16 inch deep. It will be necessary to file the tip off a 6/32 tap to permit of it cutting a thread to the very bottom of the hole. Run your tap down slowly and do not attempt to force tap when nearing the finish of the process, as it may result in the breaking of the tap. Make sure your screws are not too long. This method of mounting instruments while neat and quite effective requires considerable time, patience and care.

Dry-cell or Storage Battery Tubes?

QUESTION: I have the blueprints for a small two-tube receiver which I am planning to build. The specifications call for the use of UV-199 or C-299 tubes. If superior results could be obtained with UV-201-a tubes I would prefer to use them, if not I would prefer the dry-cell tubes. Can you help me in this problem?

THOMAS NELSON

ANSWER: We presume your receiver consists of a detector and one stage of audio-frequency amplification. In that case there will be little difference whether you use dry-cell or storage-battery tubes. As doctors the two are about equal, and also in the first stage of audio-frequency amplification. It is not until the second stage of amplification is used that the real difference between the two types of tubes becomes apparent. If there is any possibility of your adding another stage of amplification at some later date, therefore, we would advise the use of UV-201-a type of tubes.

Loudspeaker Operation on One Tube

QUESTION: Is it possible to operate a loudspeaker on one tube?

E. DUNLAP

ANSWER: With some models, laboratory built, and using special circuits, this has been possible. For this purpose super-regeneration has, as a rule, been employed. This necessitates a complicated filter system and is therefore not practical for the average broadcast listener. A loudspeaker is not an amplifier and simply transforms the electrical energy which it receives into sound energy.

Rushing Noises in a Receiving Set

QUESTION: Kindly explain the reason for the rushing noise that you hear before music is heard from the broadcasting station.

F. FARMER

ANSWER: The broadcasting station first produces a carrier wave of its specified wavelength, sends it through the microphone and to their antenna. This is the cause of the rushing noise as the microphone is not an absolutely silent device.

A Short-wave Regenerative Receiver

QUESTION: Please give me the circuit diagram and the necessary information to make a single-tube receiver of the Reinartz-Zenith type. I would like this receiver to cover a range of about 30 to 100 meters.

J. ANDERSON

ANSWER: In figure 3 is shown the wiring diagram necessary to construct the Reinartz-Zenith single-tube outfit. The parts you will need for building this set are the following:

L1 and L2—hand-wound single layer coils;
L3—hand-wound choke coil;
VC1 and VC2—variable condensers, .00025 mfd.;
GC—griddenser, .00025 mfd.;
GL—grid-leak, variable;
TEL—telephones;
R—filament rheostat, 20 ohms.

The coils, L1 and L2 should be changed for various wavelength bands. The smaller coils should consist of—for L1 a single coil wound No. 18 DSC wire wound with 9 turns on a 3½ inch diameter tube tapped every 3 turns as indicated in the diagram.

Coil L3 should be wound on the same size tubing and should consist of about 6 turns of the same kind of wire.

For the medium wavelength band, coil L1 should consist of 11 turns for this waveband wire on the same size tubing and tapped every 6 turns. Coil L2 should consist of 7 turns of the same kind of wire on the same size of tubing.

For the higher wavelength band, coil L1 should consist of 36 turns of the same size wire wound on the same size tubing. Coil L2 should consist of 11 turns for this waveband.

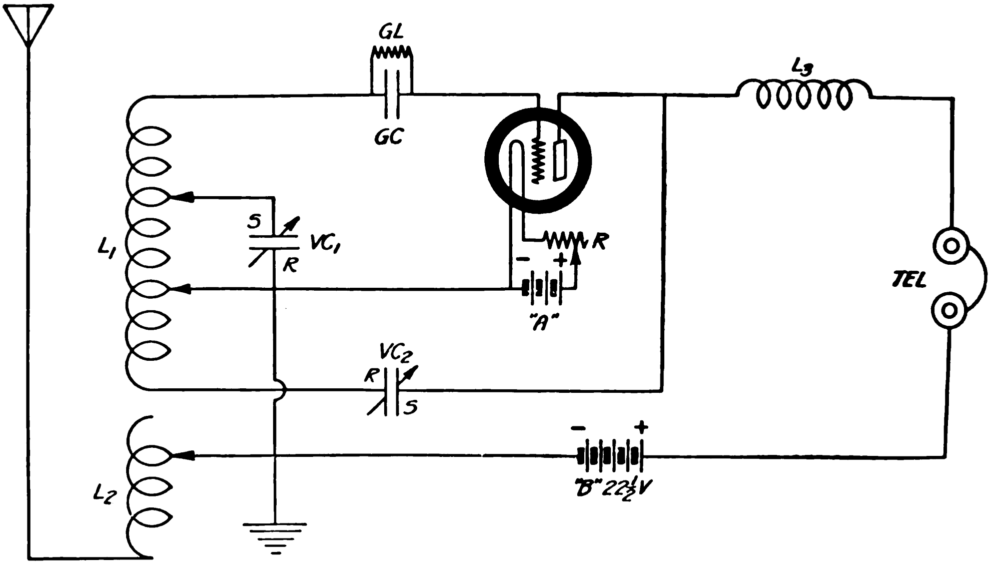
Coil L3 which is used as a radio-frequency choke coil should consist of No. 30 DSC wire wound on a form 1 inch in diameter. The wire should be wound on a wooden spool in a single layer of this section to a length of 3½ inches. An ordinary antenna of 25 to 150 feet in length should be used.

The Commercial Tube Tester

QUESTION: When buying tubes in different stores I have noticed that the reading of the tube tester varied considerably. Does this indicate that the tubes are not uniform?

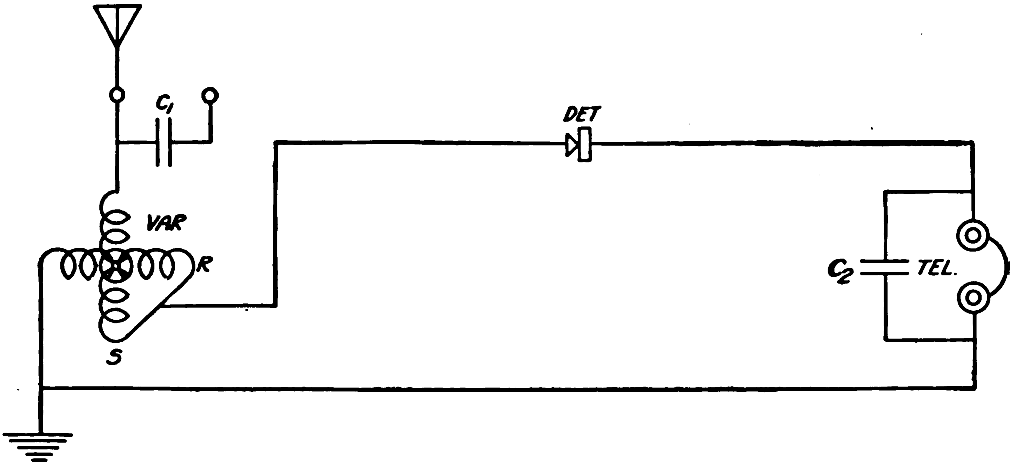
C. KANE

ANSWER: The testing device generally used merely measures the plate current of the tube for a given plate voltage and a given grid bias. One store may choose a certain value for the plate voltage and grid bias which will give them a certain reading for the plate current which they will come to recognize as a standard to judge the tube by. Another store may choose a different plate voltage or grid bias and this will give them a different standard plate current reading for the same type vacuum tube.



UNIQUE SHORT-WAVE REGENERATIVE RECEIVER

FIGURE 3: *This diagram gives the connections for the Reinartz Zenith short-wave circuit which is noted for its ease of handling on waves below 150 meters.*



A VARIOMETER-TUNED CRYSTAL CIRCUIT FOR LOCAL RECEPTION

Figure 4: *This circuit shows the electrical connections for the variometer, the two fixed condensers, a crystal detector and the telephones to the aerial and ground wires.*

A Simple Crystal Circuit

Question: Please show me how to hook up a variometer and a crystal detector in a simple receiving circuit for use with the headphones. I do not want to use any amplifier or loudspeaker with this set.

F. Collins

Answer: The circuit you require is shown in Figure 4. The parts you will need for this set are the following:

VAR—variometer;
C1—mica fixed condenser, .00025 mf.;
C2—mica fixed condenser, .0005 mf.;
DET—crystal detector;
TEL—telephone.

You should use two binding posts as indicated for the antenna circuit and connecting to the left-hand one for long waves and to the right-hand one for short-wave stations.

This receiver should give you all the local programs up to a distance of 15 miles with clear headphone reception.

Where to Locate the Loudspeaker

Question: Is it necessary to keep the loudspeaker adjacent to the receiving set? Sometimes it would be more convenient to move mine to the adjoining room.

M. E. Ford

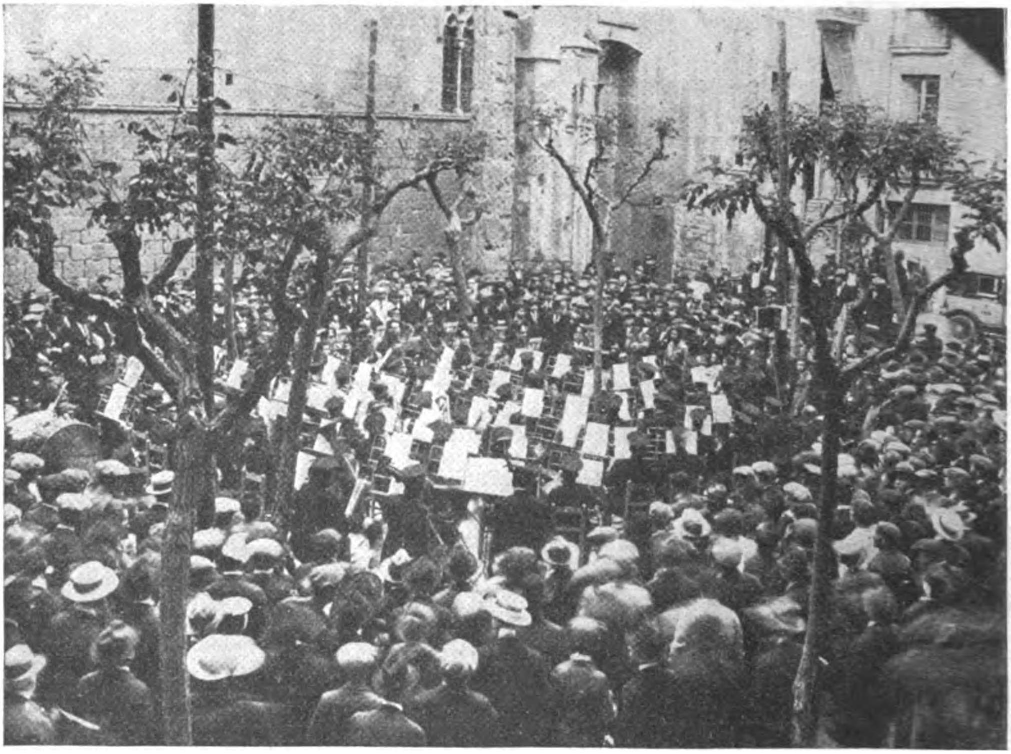
Answer: The loudspeaker may be moved a reasonable distance away from the receiving set and still give perfectly satisfactory reproduction. In fact, some manufacturers make an extension cord about 25 feet long for just this purpose. The extension cord is supplied with a plug on one end for connection to the receiving set and a jack on the other end for connection to the loudspeaker.

The "Trickle" Charger and Its Principle of Operation

Question: What is the principle of the "trickle" charger and how often must one of these be used? Is it a kind of charger that must be used in conjunction with an ordinary charger or does it replace the older type? How is the trickle charger used and what does it do? I have been told that it is used all the time that the set stands idle. Is this true? Does this cause any deterioration in the battery?

J. O. Murrin

Answer: This type of charger depends on charging the storage battery practically continuously at a very low rate. One commercial unit, for instance, consists of a very low ampere-hour capacity storage battery combined with a "trickle" charger. Permanent connection is made to the electric light socket and also to the radio receiving set and a switch is provided for lighting the vacuum tubes of the set. The unit is arranged so that the storage battery is connected directly to the receiving set while the set is in use and so that the battery is connected to the electric light mains through the charger at all other times. Thus the battery is charged continuously except while the receiving set is in use.



F. M. Delano, Paris

WHY RADIO FANS ARE INCREASING IN SPAIN

Ever since Popular Radio *initiated the broadcasting of the outdoor concerts of the Philharmonic orchestra in New York back in 1922, this particular form of "pick-up" transmission has become widely popular. Above is shown the Madrid Municipal Band playing in the Plaza del Rey; the microphone may be seen hanging on a tree.*

The BROADCAST LISTENER

Comments on radio programs, methods and technique —from the point of view of the average fan

By RAYMOND FRANCIS YATES

The WEAF Opera House

FRESH from the barber shop with a nice new hair cut and a heavy dose of Pinaud's we sat down to hear what WEAF would do to the good opera "Samson and Delilah." After it was all over we decided that this department should stop being nasty in the first paragraph and come right out and say something constructive and complimentary for a change. If we were given to the use of superlatives, we could say a lot of fine things about this good program, but we are just going to put it down as one of the ten best broadcasts of the year. This sweeping statement may mark us as one of the softest-hearted radio reviewers in the business, but this department must be kept frank and honest above all things.

There was just a tiny little bit of fault that we had to find with the presentation. The descriptive matter lacked that imaginative touch so graciously imparted by that very capable announcer, Milton J. Cross (WJZ). Cross talks easily and intelligently about the opera, and we have yet to find a man who can match his meaty prologues. It is one thing to talk elegantly and blandly about "Miserere" and the prison scene of "Il Trovatore" or the hut of the Ulrica in "Ballo Maschera," and another thing to equip the radio listeners with a vivid, living picture of the action and the *locale*. Unless there is back of it a wise old head that knows its opera and knows it well, it all amounts to so much pale pink *pfui*. If there is one thing that racks this old frame with rage it is the pathetic spectacle of an ex-usher or ex-poultry feed salesman unloading his version of "Baker's Biographical Dictionary of Musicians" into the unoffending microphone.

* * *

Opera Without the Flesh and Pasteboard

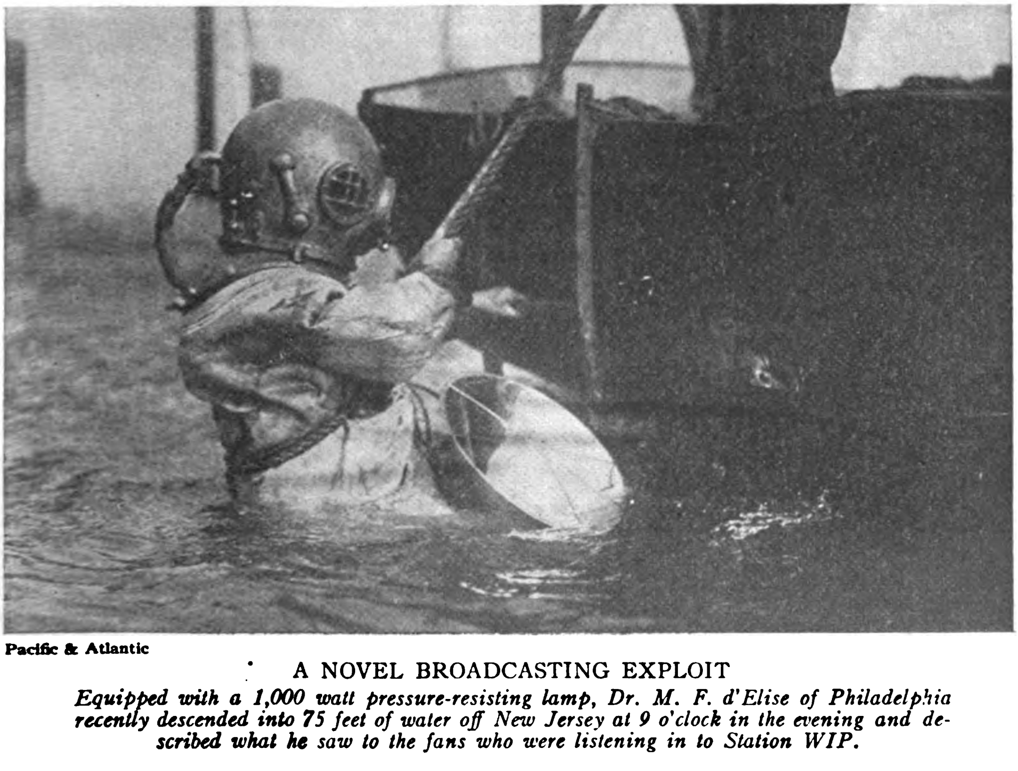
Some of our very sophisticated friends complain that the radio opera is horribly unfinished and naked without its gaudy, gilded scenes of pasteboard and papier-maché filled with the bulky and unromantic figures of fleshy tenors and sopranos. Thank God our operatic education is so incomplete and plebeian that we are cold to the demands made by the more erudite students. For one thing, we have always thought that nature has been both indiscriminate and careless in the manner in which she bestowed gifts of voice and physical charm, and it is no tragedy in the life of this reviewer to be spared the sight of the bulky flesh (and sometimes the reverse) that animates the average opera scene. It is maddening to see a 210-pound female waddling about the stage in a sickly and insufficient effort to depict a tragedy of Verdi's or a romance of Puccini's. The voice is willing, but the flesh says "No" with several 24-point exclamation marks after it.

It is strange, isn't it, that Mr. Ziegfeld is so successful in finding heavenly figures with grade E voices and that Gatti-Casazza is so sure to find 5,000-watt vocal chords residing in a Mack truck chassis. Perhaps the radio is very kind to us after all, in that it spares us the unpleasantness of associating bird-like sounds with the heaving bulks of the dinosauria. The radio may be blind, but thank heaven, it is not grotesque.

* * *

Too Much Chopin Is Enough

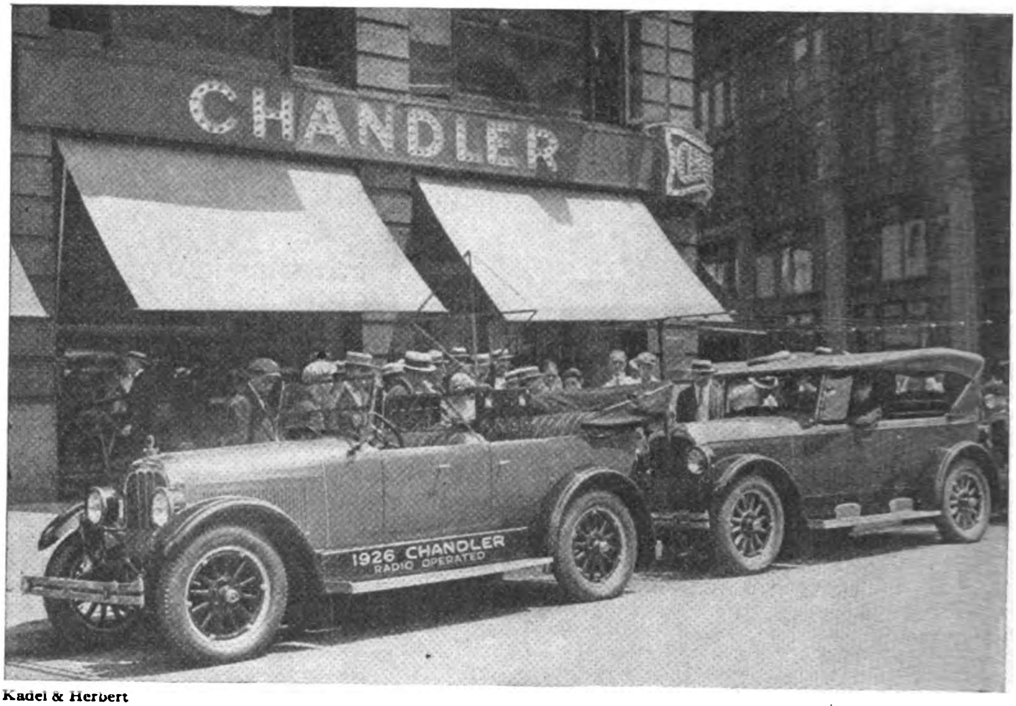
Having been a slave to the charm of Frederic Chopin's dainty nocturnes, mazurkas and études since the age of twenty (that's over forty years ago. Yes, the years do fly), we should be one of the last ones to say anything against his presence on the air. The fact that we are raising our voice a little just goes to show how serious the matter is and how upset we are about it. It seems that every pianist, near-pianist (*ditto* for the violinists) picks Chopin for public performance, and for three years now we have been Chopined on the air until we are just downright tired of it. The great "Nocturne in E Flat" has been played with all manner of technique, ranging from bright red down to Italian barber shop blue, on an average of three times a day in New York and vicinity. Let's let poor Chopin rest awhile. Men like Ernest Ball and Irving Berlin have to make a living, you know.



Pacific & Atlantic

A NOVEL BROADCASTING EXPLOIT

Equipped with a 1,000 watt pressure-resisting lamp, Dr. M. F. d'Elise of Philadelphia recently descended into 75 feet of water off New Jersey at 9 o'clock in the evening and described what he saw to the fans who were listening in to Station WIP.



Kadel & Herbert

AN AUTOMOBILE DIRECTED BY ETHER WAVES

Another experiment has recently been made with a "radio controlled" automobile, under the control unit in a pilot radio transmitter on 80 meters and operating on 100 watts; by means of relays picked up by special 5-watt receivers, the various controls of the car were operated. It has been proposed to drive the radio car and its pilot (following at a distance of 200 feet) across the continent.

Making Advertising Medicine from Old Favorites

Our advertisers, now that they have taken to the radio, are certainly getting nice and clever in putting their stuff over on the radio audience. For a time there we thought they were going to run out of ideas, but it seems that we made a bad mistake, for it was only yesterday that we heard a New York furniture installment house start its half hour off with "Home Sweet Home." If Payne and Bishop wrote "Home Sweet Home" to bring on the furniture buying mood, it was nothing more or less than a dirty trick. Anyway, this is just a little warning to be on the watch for these subtle little pieces of air-copy designed to set the good wife off on a buying streak.

* * *

Familiar Airs Ready for Cold Storage

When the announcer says that the next number is going to be "an old favorite," that means that you are supposed to like it, or at least that the chances are pretty good that you will like it. We have a large number of "old favorites," but whether or not a thing will be an old favorite with you depends upon what kind of music makes up your diet. Some like it harsh, some mild, some tender, some sentimental, some jazzy and some heavy. Some think "Marcheta" is or should be a classic (which reminds us, by the way, that it is pretty closely related to the "Merry Wives of Windsor" overture; hum the first few bars of each and listen for yourself) and others believe that Rimsky-Kosakow's "Coq d'Or" is a mere mess of unrelated and themeless notes.

At any rate, our announcers are too sure that they know the "old favorites," and it seems to us that is just a way they have of passing off the old, stale ones so they won't sound so bad. We're a wise old bird, and just to show these youngsters that they can't sell us quite so cheaply as that we are going to list a few "favorites" that should be kept off the air for the remainder of this year. It has reached a point where somebody has got to put a stop to this old favorite business, and it might just as well be us.

"Pale Hands."

"Kiss Me Again."

"Give a Man a Horse He Can Ride."

"At Dawning" (we're real mad about this one).

"By the Waters of Minnetonka."

"My Laddie."

"Tommy Lad."
"Sunrise and You."
"My Curly Headed Baby."

* * *

The Craving for Broadcast "Stunts"

It's marvelous the way the studio publicity men think up ways and means of keeping up their lineage in the daily press. If they are not writing silly paragraphs about this or that "well-known star" they are molding up a new scheme to put the station on the air with some sort of "first-time-it-was-ever-done" stunt. The prize for this sort of business goes to the young scheme-specialist who thought of broadcasting from a diver's suit at the bottom of the ocean at Atlantic City. Although the news item was probably handled through at least twenty-five press associations and appeared in every great American daily, this bellicose old thing saw in it not a single sign of merit. It is no trick to carry a microphone to the bottom of the Atlantic. It would be no more difficult than the simple trick of broadcasting from the ice box of a kosher meat market in the Bronx. It would probably be the first time anybody had broadcast from the ice box of a kosher meat market in the Bronx, and with the aid of the thousands of industrious, news-grabbing editors we have throughout this big country of ours, the thing would go over big. Some day we are going to write a big thesis on this publicity bunk over the radio, and when we do a lot of these smart publicity men are going to be told a few things. Yes, sir!

* * *

1,800,000 Compositions Broadcast Yearly

It is little wonder that the radio often loses some of its charm and freshness when we stop to think of how many hungry broadcasting studios we have that must be fed. Working on the theory that 300 studios are hard at it every day, and that each studio broadcasts at least twenty different musical numbers each day, we find (leaving out the Sundays), that no less than 1,800,000 compositions run through the mill yearly. That's eating up our musical resources at a pretty fast rate when you come to think it over. You know it has been worrying us a lot lately that radio may sooner or later make a positive bore out of the very best music. Give the public too much of anything, be it Beethoven or be it Berlin, and it eventually becomes fed up.

With that robust figure of 1,800,000 in mind we can see how it is that so many "Tommy Lads," "At Dawning" and "By the Waters of Minnetonkas" have to be thrown in to keep the broadcast pot boiling. Still that's the American way of overdoing things, feel about it as you may. In another five years we shall either be a very musical nation with every tot able to whistle Bach, Saint-Saëns and Mozart, or we shall learn to loathe the very sound of music.

Now that the world has been warned, we feel that we have done our part. Take your course, stupid old world, but don't blame us for what happens!

* * *

Proposed Rules of Conduct in a Station

If we ever own a broadcasting station (God knows we have never craved such a thing, for we are a very lazy and indolent person) we are going to post a long list of rules for the conduct of those who perform acoustically before the microphone.

Rule No. 1 would warn each speechmaker against the facetious practice of referring to the microphone as (1) ash receiver, (2) tin pan and (3) pill box. If there is one thing that causes much biting of the finger nails out in the Morris Heights section of the Bronx where these brisk little paragraphs are pecked off, it is the gentleman who slips into his subject with, "Well, folks, this is my first offense. This little dish pan before me here—"

Rule No. 2 would read, "Pat and Mike were kicked down the stairs from this studio six months ago. Do not refer to them over the air." Speechmakers calling upon Pat and Mike stories would be severely dealt with. Mr. Rube Goldberg would be hired to devise an apparatus so that the mere utterance of the words, "That reminds me of the story of Pat and Mike," would release from a point directly over the microphone a large basket of paving bricks, each one with the power to induce long periods of butterfly chasing.

* * *

Riding to Fame on Radio

Fame is a funny thing after all. Here we have been struggling along for sixty-four years and we have yet to hear somebody whisper, "Why, don't you know that guy, he's the man who—" You can do many things to become famous. Chorus girls shoot millionaires and get sentenced to six months in vaudeville. Just do something unusual, something big or something sensational, and you'll cash in. At least that formula held until broadcasting came along.

If you are a persistent sort of a person you can become famous on the air just about as cheaply and as thoroughly as you wish. Take some of our famous announcers for example. They're famous not because they're particularly good, but because they do a lot of talking that is heard by a large number of people and they keep at it. By the same process you could make a nanny goat famous by putting him (or her) near the monument at Columbus Circle. The nanny goat would do nothing to merit fame, but thousands of people would see it every day and finally people would begin to talk about the nanny goat at Columbus Circle.

Yes, these radio people ride to fame in an easy way, and here we are, just nobody, writing a wonderful line of stuff like this. Justice? Bah!

WHAT'S NEW IN RADIO APPARATUS

THIS *department is conducted by* POPULAR RADIO LABORATORY *for the purpose of keeping the radio experimenter and the broadcast listener informed concerning the newest inventions and the approved developments in radio equipment. Only such apparatus as has been tested and endorsed by the Laboratory is noted in these columns.*

AN EFFICIENT TUBE

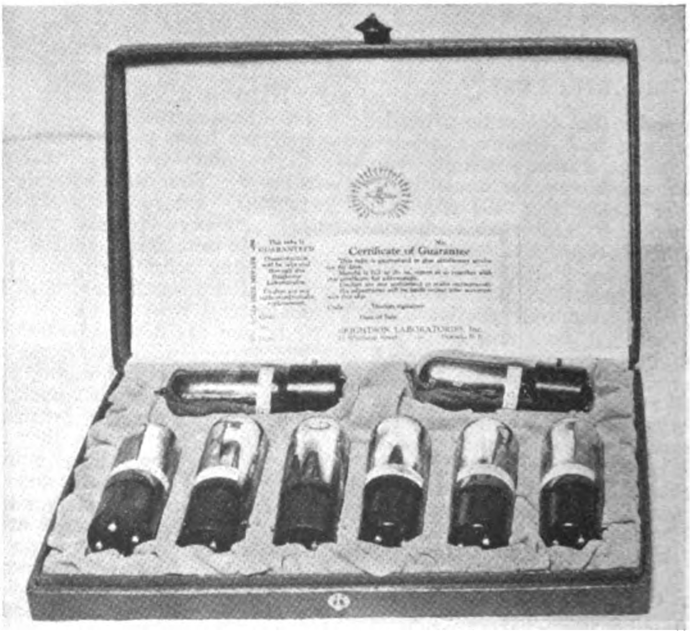
Name of instrument: Vacuum tube.

Description: This tube is made in a somewhat similar manner to the ordinary standard tube, except that a different kind of filament is used. The base is of mahogany-colored bakelite with silver-tipped terminals on the bottom. The glass portion of the tube is of blue glass with straight sides rather than the ordinary pear-shape that is used on most vacuum tubes. The tube characteristics run very uniform and make the tube extremely satisfactory for radio-frequency amplification, although they may also be used with good results as detectors and audio-frequency amplifiers.

Usage: As an amplifying or rectifying device in a radio receiving set.

Outstanding features: Uniform in electrical characteristics, sturdy construction, good appearance, efficient.

Maker: Brightson Laboratories, Inc.



These tubes come packed in a carton as shown in the illustration. They are well protected from shock and breakage in this kind of a case.

A NEW TYPE OF JACK

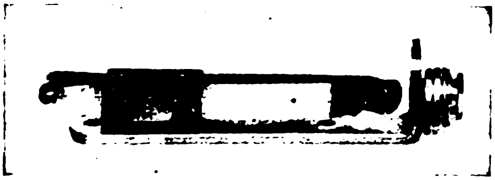
Name of instrument: Two-stage jack.

Description: This accessory is novel, in that it may be installed in a radio receiving set for controllng one or two stages of audio-frequency amplification. By inserting a plug into this jack until the first notch is encountered one stage of amplification may be cut into the circuit, and by pushing the plug all the way in the two stages are automatically attached to the loudspeaker. This eliminates the use of one extra jack and allows the operator to control the volume with a single operation.

Usage: In connection with radio receiving apparatus for attaching loudspeaker or phones to the amplifier.

Outstanding features: Neat workmanship. Novel connection feature. Good appearance.

Maker: Leich Electric Company.



A jack that performs double duty.

A NOVEL CABINET LOUDSPEAKER

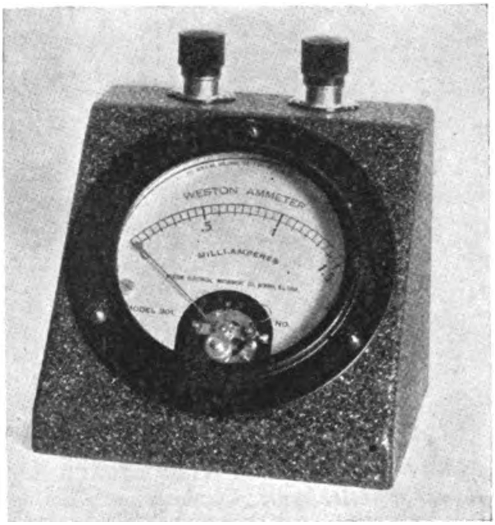
Name of instrument: Loudspeaker.

Description: Here is an electrical-acoustic reproducer which is in a low cabinet and may be placed directly underneath the receiving set. It contains a well-known make of an electric reproducing unit with a new design of flat horn which gives good tone quality and ample volume for the ordinary living room.

Usage: With any radio receiving set as a reproducer.

Outstanding features: Novel shape and design. Good tone quality. Very fine appearance when installed.

Maker: Timbretone Mfg. Co.



A quality instrument useful to any experimenter.

AN ACCURATE MILLIAMMETER

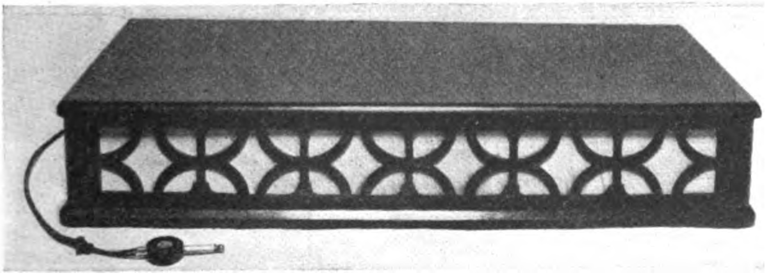
Name of instrument: Milliammeter.

Description: This is a standard size flush mounting meter of the moving coil type with a scale of 0 to 1½ milliamperes. It is also furnished in 0 to 25 and 0 to 50 milliamperes, which latter sizes are suitable for insertion in the plate circuit of radio receiving sets. For laboratory use the instrument can be mounted on a small metal bracket as shown in the photograph, which contains two binding posts at the top that may be connected to the binding posts on the instrument with two short lengths of wire. This makes the instrument serve a double purpose for both mounting in the set and for separate work in laboratory testing.

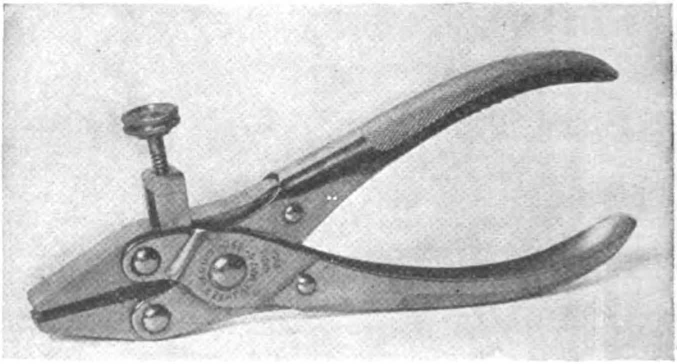
Usage: Can be mounted directly on a panel of a receiving set or as shown above for portable laboratory work.

Outstanding features: Neat in appearance, accurate, sturdy in construction, standard finish.

Maker: Weston Electrical Instrument Company.



This loudspeaker may be set on top of or underneath the ordinary receiving set. It takes up but small space and is very attractive in appearance.



This hand plier contains the novel feature of a small vise-like attachment which enables various objects to be clamped tightly in the plier without holding the two handles compressed together.

HANDY PLIERS WITH VISE ATTACHMENT

Name of instrument: Combination pliers and clamp.

Description: A simple pair of pliers equipped with a spring that holds the jaws open under ordinary conditions. At the side of the jaws is a small nut and clamp that can be used for holding an article tightly in the jaws without pressure on the handles. The workmanship is such that this tool should be useful over a long period of time.

Usage: In the experimental laboratory for holding and clamping small bits of metal or small units while building a receiving set.

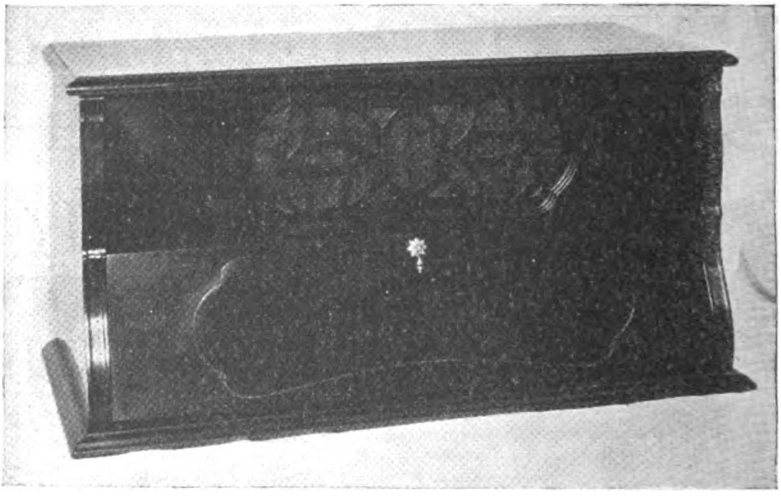
Outstanding features: Extremely handy. Light weight. The small clamp helps in holding pieces of apparatus without remaining in the operator's hands.

Maker: Wm. Schollhorn Co.

COMBINATION CABINET AND HORN

Name of instrument: Complete cabinet for a radio receiving set.

Description: A fine cabinet that is at the same time exceptionally beautiful in design and very satisfactory for encasing a home-made receiver. It is made of finely polished mahogany and is really an attractive piece of furniture. A loudspeaker horn is incorporated in the top portion of the cabinet and is all ready to have the unit clamped in position. The lower portion of the front is on a hinge which opens outward and leaves a space for writing down call letters, etc. Directly in back of this door is the section taken up by the receiving set which is installed by fastening the panel at each end with screws to a sloping or straight guide. The cabinet is suitable for mounting either a sloping panel or a straight panel as the builder desires,



This beautiful cabinet has a folding door in front that opens to the receiver. The loudspeaker is incorporated in the upper portion.

by simply reversing two triangular pieces, one at each side on the inside of the cabinet.

Usage: As a housing for a radio receiving set and loudspeaker unit.

Outstanding features: Fine appearance, simplifies the radio receiving set by housing batteries and loudspeaker. A real piece of furniture.

Maker: Blandin Phonograph Company, Inc.

A FILAMENT TRANSFORMER FOR RESTORING TUBE FILAMENTS TO ACTIVITY

Name of instrument: Tube rejuvenator.

Description: This instrument contains in a metal case a transformer with an attached winding which is suitable for applying the proper voltages to the thoriated filament vacuum tube to activity. It contains the sockets for both types of tubes and two sets of switches for applying the heavy and the light currents for this work. It is equipped with a long extension cord with a plug for installing in the lighting socket.

Usage: For restoring wornout filaments.

Outstanding features: Compact. Easy to operate. Economical in operation.

Maker: Jefferson Electric Mfg. Co.

A device for making new tubes of old ones.

A NEW BRACKET FOR MOUNTING SUB-PANELS

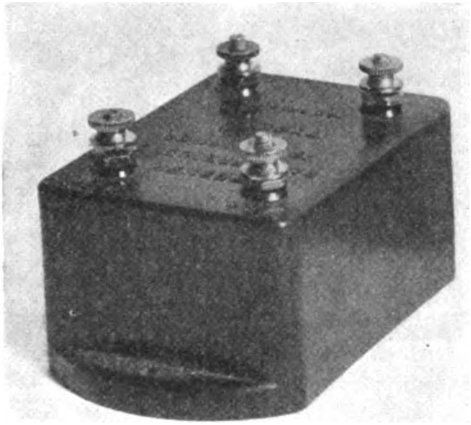
Name of instrument: Aluminum bracket.

Description: This light and strong aluminum bracket (which goes by the name of "Kelbracket") is cast in a single piece in the shape shown in the illustration with suitable holes for accommodating screws and bolts for attaching to the main panel and sub-panel of a radio receiving set. This makes a very useful accessory for the amateur and experimenter to keep on hand at all times.

Usage: As a brace and mounting for the panels in a radio receiver.

Outstanding features: Light weight. Strong. Easy to install. Neat in appearance.

Maker: Keller Company.



A radio-frequency transformer of merit.

A NEW RADIO-FREQUENCY TRANSFORMER

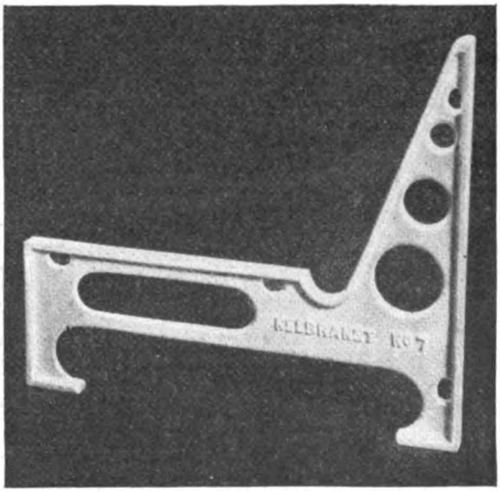
Name of instrument: Radio-frequency transformer.

Description: This is a fixed transformer, the coils of which are enclosed in a neat case with the terminals brought out at the top and plainly marked. The coils are of novel construction as is also the magnetic path that couples the two circuits together. The coils embrace the usual broadcast range. The terminals are brought out in the conventional manner on the top of the case and are marked with letters which indicate the proper connections to the coupled vacuum tubes.

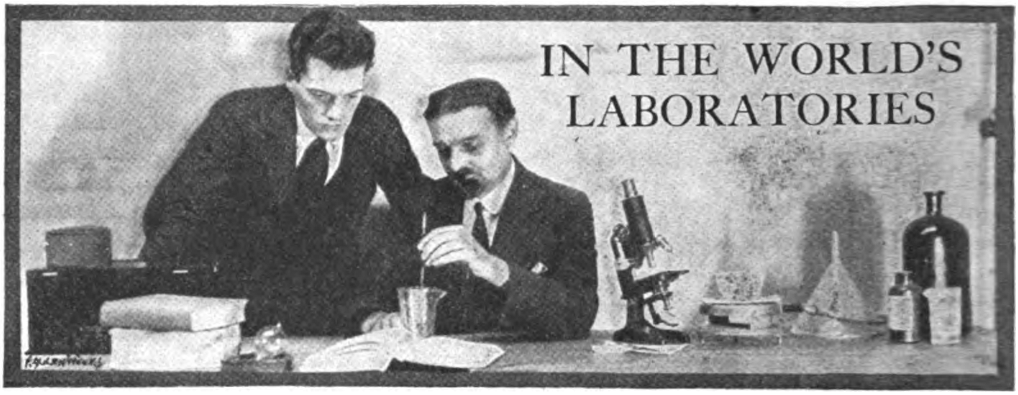
Usage: In a radio-frequency set as an interstage coupling at radio frequencies.

Outstanding features: Easy operation. Extended waveband. Neat construction.

Maker: Werner Radio Mfg. Co.



An aluminum bracket that is light and strong.



CONDUCTED BY DR. E. E. FREE

Is the Electron Divisible?

MODERN students of electricity have grown accustomed to regard electrons as the ultimate, indivisible particles of electricity. All electrons are assumed to be alike. They are believed all to carry exactly the same electric charge. It is felt that no smaller electric charge than this could exist in nature. On these fundamental principles are based the deductions of all modern electric theory. For example, these principles underlie the theory of the radio vacuum tube.

During the past few years, however, Professor Felix Ehrenhaft, head of the Physics Institute of the University of Vienna, has been attacking this view.* It is possible, he maintains, to detect fractional parts of an electron. He believes that the experimental evidence does not favor the idea of uniform electrons at all. If electrons exist, they must be variable, he thinks, in the charge that they carry. Quite possibly electrons do not really exist at all. Electricity may not be composed of particles. Instead it may really be some kind of continuous "fluid," as used to be supposed before the electron was discovered. These are his suspicions.

It is impossible to exaggerate the importance of these criticisms to modern theories of electricity and radio. Were Professor Ehrenhaft's conclusions proved correct it would be necessary to abandon almost everything that we believe about vacuum tubes, about the electro-chemistry of storage batteries, about the structure of atoms, about the photo-electric cell and about a score of other physical developments. Fortunately, it is the almost universal opinion of scientists that Professor Ehrenhaft is mistaken.

In connection with the publication of the professor's paper in the *Philosophical Magazine*, Sir Oliver Lodge (who is one of the editors) prints a note saying that it is impossible to agree with Professor Ehrenhaft but that his paper is presented in fairness and in order that there may be no claim that a viewpoint has been ignored.† The editor of *The Physical Review*, Dr. Gordon S. Fulcher, appends a similar note to the paper of Mr. Sexl referred to in the preceding footnote. More important still, Professor R. A. Millikan. himself contributes a review of the available evidence, with especial reference to the conclusions of Professor Ehrenhaft.‡ No valid evidence has been adduced, Professor Millikan concludes, to weaken at all the idea that all electrons are indivisible and that they carry the same electric charge.

So far as we know, Professor Ehrenhaft's ideas have not attracted the attention of radio engineers outside of Austria. But perhaps they will do so, and it is as well for the radio public to realize that the professor's peers in the field of physics do not agree with his conclusions.

Exploding Wires with Forty Thousand Amperes

ABOUT five years ago Dr. J. A. Anderson, of Mount Wilson Observatory, devised an ingenious and spectacular method for studying the behavior of atoms of metals under the influence of high electric densities and tremendous heat. He built a great condenser of glass plates and sheets of tin foil. It had a capacity of one microfarad and could be charged to 20,000 volts. The entire charge of this condenser was then allowed to pass through a tiny metallic wire. Of course, the wire instantly blew up. By observing the spectrum of the light given out by the flash Dr. Anderson obtained valuable information concerning what happened to the atoms caught in what was, for them, so tremendous a cataclysm.

---

* Professor Ehrenhaft's first communication on this subject was presented to the Vienna Academy of Sciences on March 4, 1909. His views are summarized, by himself, in a recent paper entitled "The Electrical Behavior of Radioactive Colloidal Particles of the Order of 10^{-6} Centimeter as Observed Separately In a Gas." *The Philosophical Magazine* (London), vol. 49, pages 633-648 (April, 1925). There is another recent paper by Th. Sexl (a pupil of Ehrenhaft) in *The Physical Review* (Corning, N. Y.), vol. 26, pages 92-96 (July, 1925).

† In *The Philosophical Magazine*, following Professor Ehrenhaft's article just cited (page 648).

‡ "The Nature of the Evidence for the Divisibility of the Electron," by R. A. Millikan, *The Physical Review* (Corning, N. Y.), vol. 26, pages 99-104 (July, 1925). It was Professor Millikan, as all radio fans should know, who proved the existence of the electron and measured its electric charge. This fundamental research is described in "The Electron," by R. A. Millikan, first edition issued by the University of Chicago Press in 1917; second and revised edition (the latest), 1924, 293 pages.

Several investigators have worked with this method since Dr. Anderson invented it * and now Mr. Sinclair Smith, working under the direction of Dr. Anderson himself, has added to the method a way of determining the time of the explosions and of discovering how the behavior of the atoms alters as the explosion proceeds.† To do this Mr. Smith allows the light from the exploding wire to fall on a moving mirror which reflects the light, in turn, onto the photographic film on which the record is made. The photograph of the flash is thus spread out over a certain length of the film, as it would be in a motion picture record, but with a much greater "time resolving power." This last expression means that changes occurring in much shorter time intervals can be detected and studied. It has proved possible, in fact, to detect, with some precision, the progress of the explosion in a time as short as one millionth of a second.

This time is not much longer than the times required for some of the changes inside the atoms themselves and work with this method will probably result during the next few years in greatly increased knowledge of the most intimate atomic secrets. A few of the facts already disclosed are indicated by the spectrum photographs reproduced herewith. They are set forth in more detail in Mr. Smith's paper already referred to.

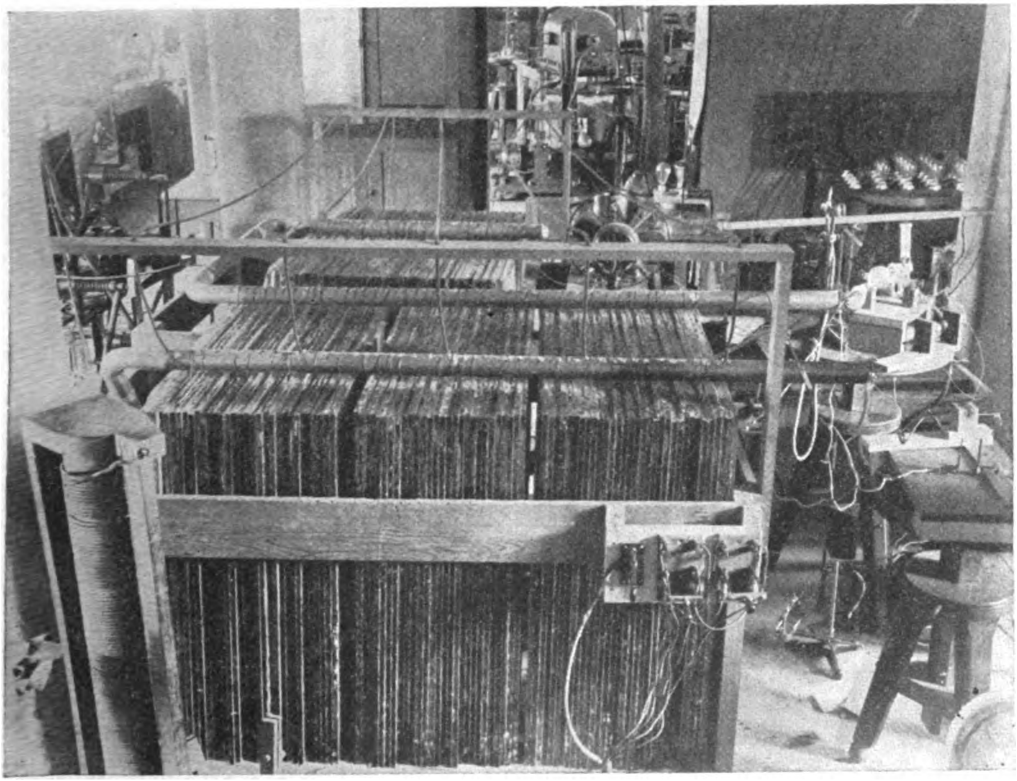
Radio engineers will be especially interested, however, in the constants of this tremendously powerful oscillating circuit and in the novel construction used for the new condenser which Mr. Smith has constructed.

The original condenser built and used by Dr. Anderson was made, as already noted, of glass plates carrying sheets of tin foil. Ordinary window glass was used. The tin-foil sheets were 17 by 21 inches, there were 200 glass plates and

---

* An account of some of this work was given in this department in POPULAR RADIO for February, 1925, on pages 185 to 187.

† "A Study of Electrically Exploded Wires," by Sinclair Smith. *The Astrophysical Journal* (Chicago), vol. 61, pages 186-203 (April, 1925). We are indebted to Dr. Walter S. Adams, Director of the Mount Wilson Observatory, and to Dr. Anderson for some additional information concerning the apparatus, as well as for the photographs reproduced herewith.



Mt. Wilson Observatory.

THE GIANT CONDENSER USED TO EXPLODE WIRES

The glass-plate condenser in the foreground has a capacity of .6 microfarad at 60,000 volts. The electricity stored in it is discharged suddenly through a tiny wire stretched between the two upright terminals seen on the table at the right. The wire instantly explodes, its light yielding information about the behavior of the atoms in it. The wooden block on the table, just behind the spark terminals, contains two other terminals used for explosions in confined space.

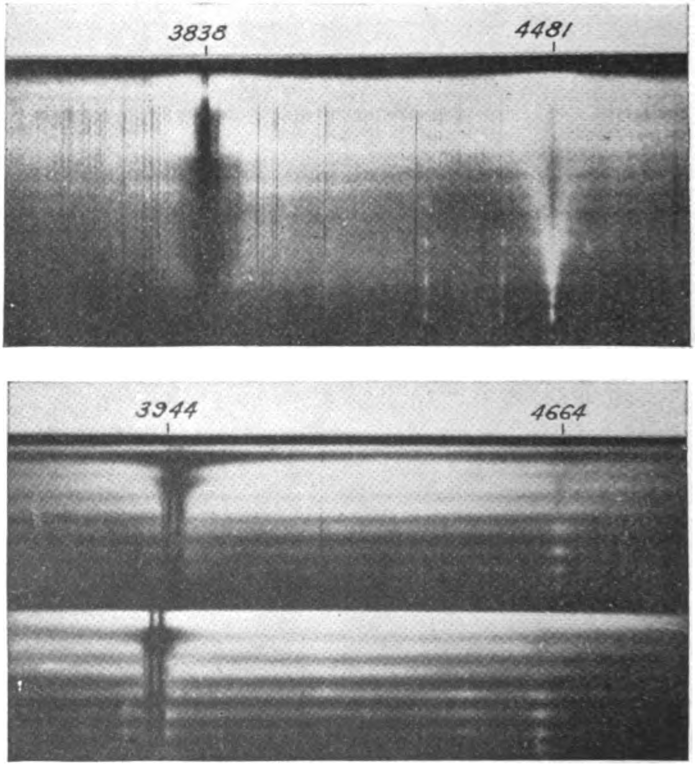
the capacity attained was one microfarad, at a potential difference of 20,000 volts. In the new condenser of Mr. Smith the tin foil sheets are discarded. The conductors are fine-mesh wire screens placed inside the substance of the glass plates, just as wire reinforcing material is placed, nowadays, inside the sheets of fire-resistant glass. The wire is inserted in the molten glass when the sheets are being made.

In the wire-and-glass sheets used by Dr. Smith a connecting wire was brought out at one edge of each sheet. The condenser was assembled in such fashion that these connecting wires came out, alternately, at opposite ends of the condenser. Thus the wire screens were charged, alternately, positively and negatively. The dielectric between them was formed by the surrounding glass. With this condenser, while the capacity was only about .6 microfarad, the potential difference attainable was found to be as high as 85,000 volts. Only 55,000 to 60,000 volts were used in the experiments now reported.

It is worth noting that the wire-glass sheets employed were made by the Mississippi Glass Company. This material ought to prove useful for many purposes in radio experimentation and in physical laboratories generally.

When operated with a 55,000-volt charge the frequency of the oscillations set up on discharge was found to be 185,000 cycles per second, which means 185 kilocycles and corresponds to a radio wave of approximately 1,620 meters. The maximum of the current at the peak of each half-cycle (one peak being for current in one direction, the other for the reverse current) reaches the tremendous figure of about 40,000 amperes. Of course this large current endures for only a tiny fraction of a second; perhaps for even less than the one millionth of a second which is the limit of the time-resolving power of Mr. Smith's apparatus. If it does last for one millionth of a second, the number of electrons that cross the gap where the wire was during that instantaneous period reaches the virtually incomprehensible number of 250,000,000,000,000,000.

It must be remembered, too, that these electrons surge back and forth several times across the gap where the wire blew up. Each

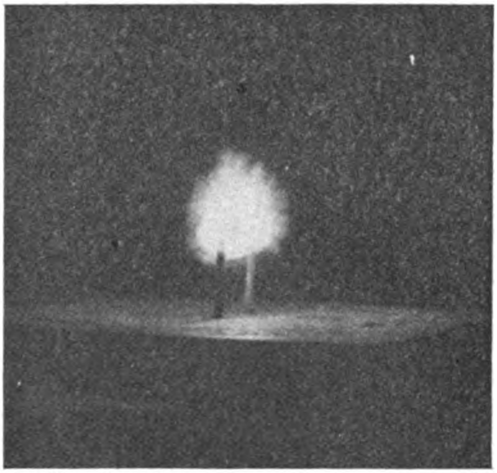


Mt. Wilson Observatory.

THREE RECORDS OF EXPLODING WIRES

The explosion begins with the white edge at the top of each record. Time is measured downward, the entire first record covering about one twenty-thousandth of a second. The horizontal bands of light correspond to the surges of current back and forth through the condenser. The top record shows the explosion of a wire of metallic magnesium. Note that the spectrum line marked as having a wavelength of 4,481 Angstrom Units is at first a dark (absorption) line, then a bright line. The two bottom records show explosions of aluminum wires.

complete cycle of the discharge means one surge forward and another surge back. It is like passengers rushing from one side of a steamer to the other and then back again as the boat begins to list. With each peak of current, on each half-cycle of the oscillation, the metal atoms of the exploded wire glow brilliantly. That is what causes the horizontal bands so clearly visible in those of Mr. Smith's spectra which are reproduced herewith. These bands are actual pictures of the effects of the condenser discharge on the metal atoms



Mt. Wilson Observatory.

EXPLODING AN IRON WIRE

This picture shows the actual appearance of the explosion when the full charge of the giant condenser is sent through a thin wire of iron.

Broadcast Interference in Europe

In the nature of the case there can be no central authority in Europe with power to assign wavelengths and to regulate in other matters the activities of broadcasting stations in the various nations. The result is a growing difficulty from interference of one station with another. For long-distance work the European ether is already well "jammed."

To attempt the solution of this situation the European broadcasting interests have organized an informal international Bureau at Geneva, Switzerland. Mr. Arthur Burrows, formerly an official of the British Broadcasting Company, has been made director. Since Mr. Burrows has no actual power to enforce any regulations which he may make, his task will be a difficult one. This has been indicated already by the failure of the first international broadcasters' conference, held at Geneva during July, to reach any decision whatsoever on the very vital question of apportionment of wavelengths.

At this note is written, it is the intention to conduct a series of general interference tests during the first week of September, in the hope of discovering which stations will be likely to interfere with each other in the various parts of Europe. The same wavelengths will then be assigned to stations which are far enough apart to show no interference within their usual range of distance.

Radio for Both Ears

A system of "binaural" radio—which means, literally, "two-ear" radio—was invented some months ago by Dr. F. M. Doolittle of Yale University and was described in the invention department of Popular Radio.* It has now been put in operation at an experimental transmitting station at New Haven, Connecticut.†

The idea is that ordinary radio fails to seem perfectly natural to the ear because the microphone which picks up the sound occupies only one point. In normal hearing we hear with *two* ears, slightly separated in space. Thus we get a kind of "space sense" in our hearing, just as our two-eye vision gives us a sense of depth and solidity. Dr. Doolittle substitutes for the single microphone, two microphones. These are placed at a little distance from each other. The sound waves received by them will differ slightly, just as do the sound waves received from an orchestra by the two ears of a listener.

The modulations of the two microphones are broadcast separately, on separate channels. They are also picked up and detected separately. One is fed into one ear of the listener; the other into the other ear. The result is said to be a greatly improved "naturalness" of the sound.

As at present operated, the system requires two entirely separate transmitting circuits, two channels and two receivers. It is doubtful if this is within the range of practicable utility. It is suggested, however, that the separate modulations might be impressed on two intermediate frequencies, between the radio and audio ranges, and that these two frequencies might then be combined as a modulation on a single radio-frequency carrier wave. A receiver equipped with properly tuned filter circuits could be made to separate these intermediate frequencies, supplying the audio-frequency modulation of one to one ear and of the other to the other ear. Whether the increased enjoyment of the listener would be worth the trouble and cost is none too certain, but at least it would be worth a careful trial.

The "Radio Detective"

The possible use of radio devices to prevent thefts from factories and similar establishments has been often mentioned. It remained for the German firm of Wetsel Brothers, in a suburb of Leipzig, to put this apparatus in a practicable and commercially useful form. The radio principles used have been worked out for this firm by two Leipzig physicists, Dr. Geffcken and Dr. Richter.*

---

* "With the Inventors," in Popular Radio for April, 1925, page 392.

† "Binaural Broadcasting," by F. M. Doolittle, *The Electrical World* (New York), vol. 85, pages 867-870 (April 25, 1925).

* Information for this note is from a statement kindly supplied by Gebr. Wetzel, Leipzig-Plagwitz, Germany, July 11, 1925.

The device consists of a door through which all workmen are compelled to leave the plant and which is surrounded by a wire carrying a radio-frequency current. The frequency of this circuit is carefully tuned. If any workman attempts to carry a bar of copper or any similar metal object through the door, concealed inside his clothes, the induction between this metal object and the surrounding circuit will alter the tuning of that circuit. There will be a resultant squeal in the headphones of the operator who is in charge of the door. The offending workman can be stopped and searched. It is just as though the workmen were compelled to walk through the tuned solenoid of a radio transmitter. Every amateur knows how violently any stray metal inside such coils will upset the tuning of his circuit.

By the use of this device, search of the employees is rendered unnecessary. There is no need to require a change of clothes on entering and leaving, which is sometimes required in American factories. The great majority of honest workmen are not annoyed or delayed by the possibility that a few are dishonest. Of course, the apparatus will detect only metal objects. It would be useless on non-conducting things like glassware or silks or foodstuffs. Furthermore, it must be adjusted, one imagines, so that it will work only on metal objects of substantial size.

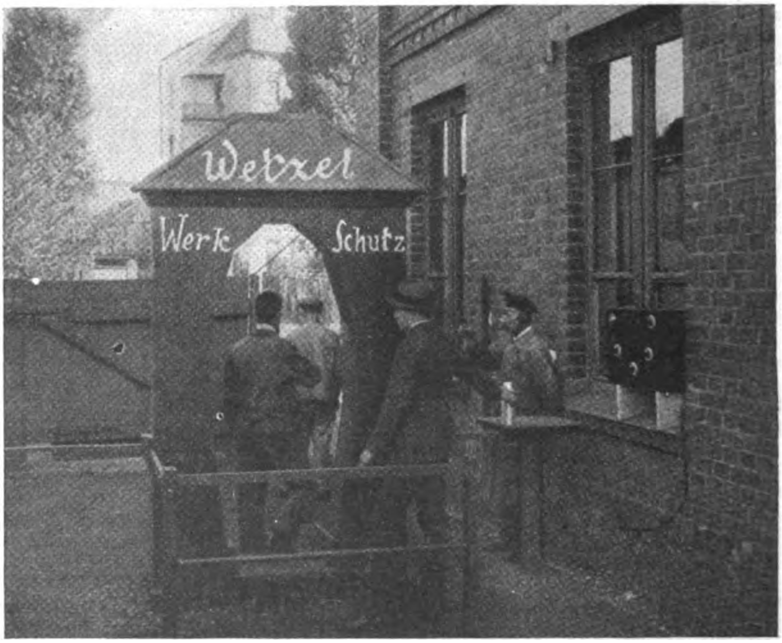
A radio detective sensitive to stickpins and suspender buttons would have obvious disadvantages.

Electrification that Lasts for Years

A DISTINGUISHED Japanese physicist, Professor Mototaro Eguchi, of the Higher Naval College at Tokyo, has reported a discovery which promises to have far-reaching effects on electron theory and, quite possibly, on radio technique. He has discovered a way of obtaining what seems to be permanent electrification, analogous to the persistent magnetism of the familiar permanent magnets. Professor Eguchi has named his new invention the "permanent electret." *

The process of making the electret is quite simple. A liquid mixture of melted wax-like substances is allowed to harden (by cooling) in a strong electric field. The wax plates thus produced are found to be permanently electrified. The wax mixture used in most of the experiments contains fifty percent of ordinary resin, presumably from some species of pine tree, mixed with fifty percent of carnaûba wax. To this may be added a little beeswax, but this is not essential.

This melted mixture is poured into shallow, flat pans like pie tins. A metal plate is then lowered onto the top of the wax mixture and a strong electrostatic field is created between this metal plate and the metallic bottom of the pan that



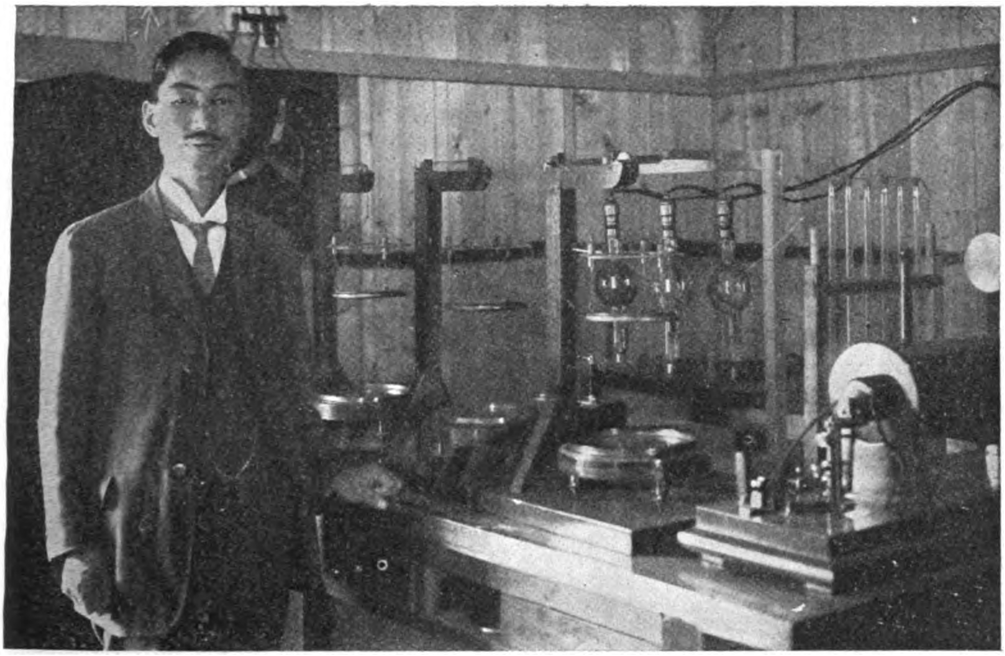
Wetzel Brothers.

SUBMITTING TO THE "RADIO DETECTIVE"

Inside the boxed sides of the gate is a coil connected to the oscillator on the window sill. If a workman attempts to carry a concealed piece of metal through the gate, the induction between it and the surrounding coil causes a warning note in the headphones worn by the operator. Metal objects legitimately carried may be stood on the small table while the gate is passed.

---

* "On the Permanent Electret," by Mototaro Eguchi. *Philosophical Magazine* (London), vol. 49, pages 178-192 (January, 1925).



From a photograph made especially for POPULAR RADIO by Professor Eguchi, Tokio.

PROFESSOR EGUCHI AND HIS PERMANENT ELECTRET

The horizontal pans at the Professor's left are those in which the wax mixture is allowed to harden under electric stress, so that it becomes permanently electrified. The plates which serve as the upper parts of the condensers may be seen suspended over the pans. The vacuum tubes supply the necessary potential.

holds the wax. The source of charge is a vacuum-tube electrostatic generator. The arrangement of the apparatus is shown clearly in the photograph kindly supplied by Professor Eguchi and which is reproduced herewith.

Essentially, the metal pan and the superposed metal plate act as the two plates of a high-voltage condenser. The wax mixture hardens while it forms the dielectric of this condenser; that is, while it is exposed to enormous electrostatic stress. After it is hard the wax plate is found to be electrified in the reverse sense to the electrification of the condenser. One side of the plate is permanently negative, the other side is permanently positive. These charges last for years. Some have lasted since 1919. The voltage reached by this surface charge may be as high as 20,000 volts per centimeter. The density of the charge on one of the plates was measured as six electrostatic units per square centimeter of the surface.

Scraping of the surface, washing it with acids or other conducting solutions, exposing it to the heat of a gas flame and similar processes destroy the surface charge temporarily, but the charge is restored quickly when the electret is allowed to stand with its surface protected by a metal plate or a sheet of metal foil. Professor Eguchi believes that the electrification is due to a fundamental re-arrangement of the electrons and atoms inside the wax mixture, an electric "polarization" which extends a substantial distance inward from the surface, if not altogether through the plate. The temporary destruction of the charge by solutions, flames and other agencies is ascribed to an accumulation of oppositely-charged ions on the surface. These annual temporarily the permanent charge of the electret. On standing, the accumulated ions escape and the permanent charge reappears.

It is obvious that these experiments are of the utmost interest from the viewpoint of atomic theory. If they are confirmed, and especially if they can be detected in plates of pure substances instead of in the mixtures actually used, they will indicate the possibility of creating a lattice structure of atoms in which there is a sufficient distortion of the atom (or electron) positions to cause a great lack of balance between the positive and negative charges. This is a new line of attack on the problems of atomic structure.

To the radio engineer another interest of the work lies in the possibility of procuring permanent electrostatic fields without the necessity of maintaining them. In the vacuum tube, for example, the positive voltage on the plate must be maintained by the "B" battery. This will probably be necessary always, so long as we use the present design of tube, for the positive charge on the plate is continually being neutralized by the arriving electrons of the plate current.

There exist, however, many experimental devices in which one wants merely an electrostatic field or charge, there being no dissipation of this charge except by leakage. An example is the electrostatic plate of an oscillograph. For such purposes some modification of Professor Eguchi's permanent electret may prove of real value. When the permanent magnet was first investigated by Dr. William Gilbert, back in 1600, no one had any use for it. Yet nowadays we would have difficulty in maintaining civilization at all if the permanent magnets of our compasses, our magnetos and other devices were taken away from us.

A Self-starter for Radio Receivers

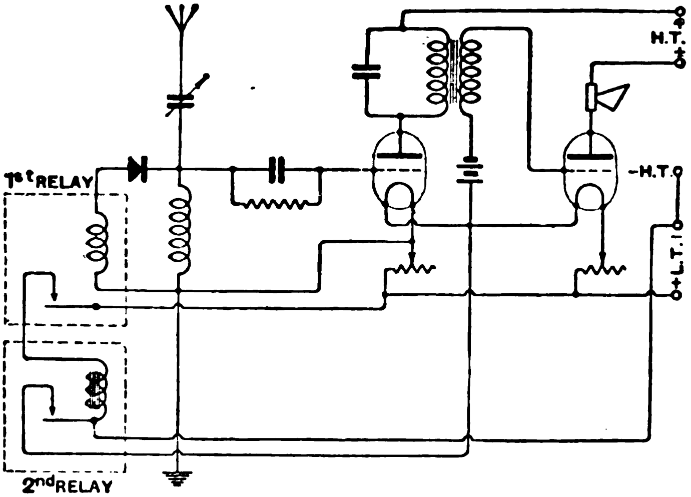
An accessory so convenient that it ought soon to find a commercial place in radio is described in a recent paper by Mr. A. P. Castellain.* This is no less than a relay which automatically stops or starts a radio receiver when the broadcast wave ceases or begins. It is necessary, in reality, to employ two relays. The first is an extremely sensitive one, consisting of a tiny coil mounted between the poles of a permanent magnet. The signal from the antenna is led through a crystal detector and thence through this coil. If any energy is received from the broadcasting station, a current is produced in this coil. The reaction of this current on the magnetic field causes the coil to move. The principle is exactly the same as that of the moving-coil galvanometer.

When the coil of this first relay moves it closes the actuating circuit of an ordinary telegraphic relay. This closes, in turn, the filament circuit of the receiver. Thus reception starts. If the broadcast wave ceases, a small spring returns the moving coil of the first relay to its neutral position, all the circuits open and reception stops.

For American conditions, where there may be several stations in the same city, it would be necessary for the crystal circuit controlling the first relay to be tuned, so that it would respond only to the station for which it was set. Thus arranged, the device should be useful not only to prevent the frequent accident of leaving the filaments burning all night, but also to turn on the set and wake up each morning those fans who are addicts of the early-morning health and exercise broadcasts now so fashionable from numerous stations. One might anticipate some danger that severe static would actuate the first relay and turn the set on when it was not wanted, but Mr. Castellain mentions no trouble from this source and static is almost as severe in England as here.

Radio Apparatus Helps to Photograph the Human Heart

The human heart is one of the most difficult things in the world to photograph. X rays permit the physician to see the heart successfully enough but that organ will not stand still to have its portrait taken. Or rather, if it does stand still, the patient will take no further interest in the proceedings. Accordingly, physicians have been searching for years for some method which would permit good heart photography. A snap-shot, made at the instant when the heart is at rest between beats, will not suffice. X rays of the intensity which it is



From the "Wireless World."

HOW RELAYS ARE USED TO MAKE THE SELF-STARTING RECEIVER

By means of the crystal detector, the antenna current itself actuates the first relay. This actuates the second relay, which then turns on the filament current for the receiving tubes. If the antenna current ceases, the first relay opens and stops the filament current. For American conditions a tuned crystal circuit would have to be used for the first relay.

---

* "A Wireless Self-Starter," by A. P. Castellain. *The Wireless World* (London), vol. 16, pages 564-566 (June 10, 1925).

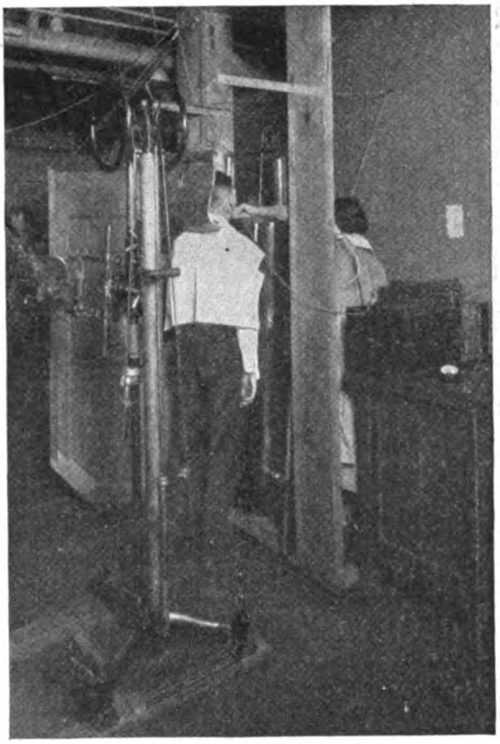
safe to send through the body are not powerful enough to make a detailed photograph so quickly as that.

The problem is important for lung photography, as well as for heart photography. The lungs are in continual motion just as much as the heart is. And many of the lung infections, especially the initial infections of tuberculosis, have a habit of occurring just in that part of the lung tissue which is near the heart and which is moved, therefore, not only by the motions of breathing but by the beating of the heart as well.

There was where the problem stood when Dr. F. M. McPhedran, of the Phipps Institute of the University of Pennsylvania, enlisted the interest of Professor Charles N. Weyl, of the Electrical Engineering Department of the same University. By employing some of the most recent devices of radio engineers, Professor Weyl has succeeded in devising an X-ray photographic apparatus which will make a satisfactory still-picture of either the heart or the lungs without making it necessary to stop the motion of these organs at all.*

The principle is that of taking a succession of short exposures, each one at exactly the same place in the cycle of heart motions. Motion picture fans are familiar with the fact that if the motion of any piece of machinery, for example, a wheel, is timed to fit the exposures of the motion picture film, the wheel will seem to stand still. Each successive exposure finds the wheel in the same position as it occupied during the preceding exposure. Professor Weyl's device does this same thing, except that all the exposures are made, one on top of each other, on the same plate. They are equivalent to a single long exposure.

Where radio comes into the matter is in the way in which the heart itself is made to control these exposures; to operate the shutter, so to speak, for its own portrait. The apparatus begins with a small glass funnel which is held against the neck of the patient, just over the carotid artery. This artery is beating, of course, in exact time with the heart. These beats are communicated to the air inside the funnel and thence, through a rubber tube, to an air-box one end of which is closed by a thin rubber disphragm. This diaphragm vibrates in time with the air-column behind it; that is, in time with the beats of the heart. Attached to the rubber diaphragm is a small mirror. A beam of light from a lamp strikes this mirror and is reflected off at an angle so that it falls on a sensitive photo-electric cell. With each beat of the heart the mirror moves. The light beam is swung alternately on and off the sensitive portion of the photo-electric cell.



University of Pennsylvania.

PHOTOGRAPHING THE HEART

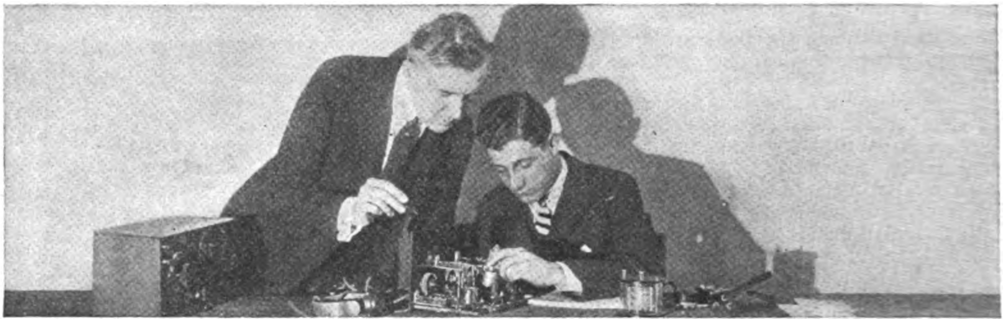
The small funnel which the nurse holds against the neck of the patient picks up the impulses of the beating heart. Through a chain of mechanical and electric relays, these impulses control the instant and length of each successive X-ray exposure.

The result is a succession of tiny electric pulses produced by the cell in exact time with the beats of the heart. Although these equal a current strength of not over ten billionths of an ampere, they are amplified by a radio amplifier of standard type until they are strong enough to actuate a relay which turns the X-ray current on or off at the exact instants desired. A lag timer permits the operator to set the instants of the successive X-ray exposures for any desired fraction of a second after the conclusion of each heart beat. Thus set, the apparatus will continue to make flash exposures at that same instant, one for each heart beat, so long as the current is left on and the small funnel is kept pressed to the artery in the patient's neck. This device is sure to play an important part in medical science.

---

* Information for this note is from a statement issued by the University of Pennsylvania, May 31, 1925.

¶ ARTICLE NO. 9 *of the series "How to Get the Most Out of Your Ready-made Receiver," in which the theory, operation and care of the Garod Neutrodyne, Type V set is treated, was crowded out of this issue of* POPULAR RADIO. *It will appear in the succeeding—November—number.*



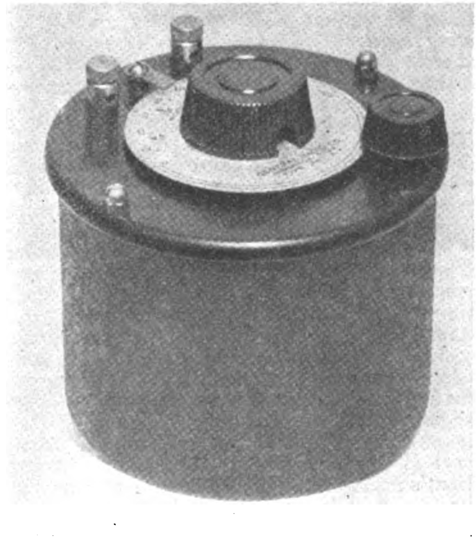
IN THE EXPERIMENTER'S LABORATORY

CONDUCTED BY LAURENCE M. COCKADAY

Uses of a Variable Condenser

ONE of the most essential pieces of apparatus for the set builder and experimenter is a standard of capacity. This should have a constant capacity value, fairly accurate calibration, variable capacity and it should be portable. (The requirements are listed roughly in the order of their importance.) The price paid for the apparatus and its importance will vary with the purchaser and his requirements.

The General Radio type No. 247 condensers (see Figure 1) satisfy these requirements very well where ordinary precision is required, and they cost about the same as the usual type of condenser. One of the 1000 mmf. (.001 mf.) types should be used, if possible, as this allows wide variation for measurement work. Where greater capacity is needed a fixed condenser or combination of them with the standard can be used. These can be measured either by the simple method given in this article or by the more complete methods to be given next month.



KEEP A CONDENSER FOR EXPERIMENTAL PURPOSES

FIGURE 1: *A small laboratory condenser is extremely useful to the experimenter. It helps him to measure the capacities necessary in a new circuit and helps him in numerous other important ways.*

As a rule the capacity of a by-pass or blocking condenser is not critical. Both of these perform fundamentally the same function of frequency selection. The only receivers which require fairly close adjustment of the by-pass condensers are the reflexes. In these the values must be varied to get best results.

Where the grid-leak is continuously variable or can be changed, the value of the grid condenser is not critical and can be varied over fairly wide limits.

The only type of circuit requiring close adjustment of the capacity is a tuned one such as the input or output circuit of a tuned intermediate-frequency amplifying transformer. Even here extremely close adjustment is not always necessary as the untuned stages generally have a broad enough amplification curve to give good amplification over quite a frequency band.

Due partly to the difficulty of manufacturing condensers of uniform capacity on a large scale cheaply, and partly to the lack of demand for such condensers, most of the condensers now vary 25 percent or so. The more progressive manufacturers are guaranteeing them within 10 percent so as to insure duplication of results in receivers having the same constants.

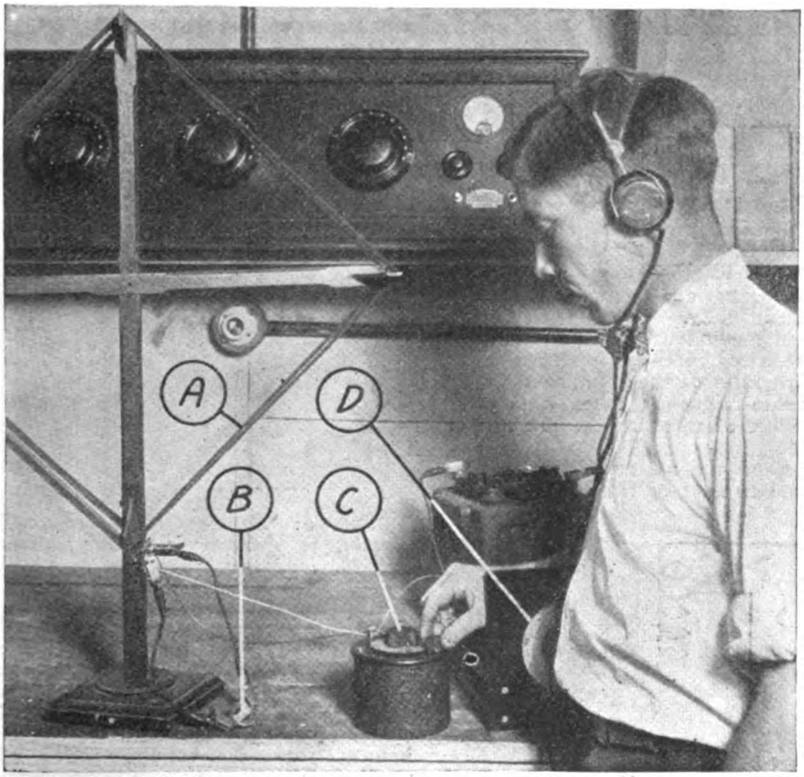
It will be apparent from the foregoing that a variable condenser which can be used to measure capacities within, say, 5 percent is sufficiently accurate. This is especially true when manufactured condensers varying by 10 percent are used without measuring their capacity with greater precision. Besides measuring capacities, a variable condenser may be used to determine the proper value to use at any point, as a substitute to determine whether or not a condenser is faulty and to measure inductances.

To measure capacities the condenser should be connected across the loop (or secondary) circuit of a receiving set. Figures 2 and 3 show the connections. A is the loop, B the unknown capacity, C the standard and D the loop turning condenser. The condenser D should be set for minimum value.

Tune in a station as near the highest setting on the variable "standard" C as possible. Then connect the unknown B across it and reduce the standard to the point where the same station is again received. Care should be taken if a superheterodyne is used to see that the new point is not one of the repeat points. The receiver should be adjusted so the loop condenser D tunes sharply otherwise the reading will not be accurate. Where it is rather broad the means of several readings will be more precise than any one reading. This is only satisfactory for measuring capacities of about 900 mmf. (.0009 mf.) or less, depending on how high a setting of the standard is used the first time and the value of the minimum capacity of the set condenser (D). More complete details of capacity measurement will be given next month.

A condenser of this type is always handy when trying out new circuits, particularly of the reflex type. It should be connected wherever a condenser is needed and tuned until the best value is found. A fixed condenser of that capacity can then be substituted. If the value is fairly critical it may be necessary to measure the capacity of the fixed condenser to be sure it is of the proper value.

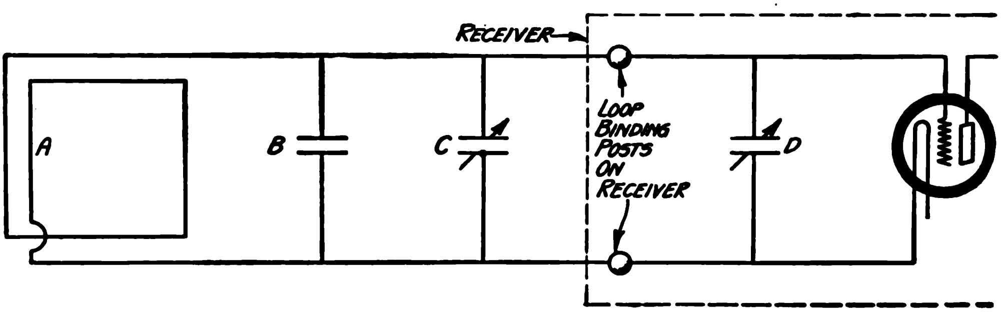
The dials on the type number 247 condensers have divisions every 20 mmf. on the capacity dial. Intermediate points have to be estimated. A valuable aid to more accurate measurement is a capacity curve. This can be made by plotting degrees setting on one side of cross section or graph paper against micro-micro-farads on the other. If, for example, the 1,000 mmf. type is bought the dial reading in degrees should be noted when the condenser is set for 1,000 and 60 mmfs. These two points should then be plotted and a straight line drawn between them. Below 60 mmf. the calibration is not accurate due to the minimum capacity of the condenser. To read the capacity at any setting read the dial setting in degrees and run up or over as the case may be to the curve (the straight line just drawn) then over or down to the capacity reading at the side or bottom of the chart.



From a photograph made for POPULAR RADIO

ONE OF THE USES OF A LABORATORY CONDENSER

FIGURE 2: *This picture shows how an ordinary receiving set connected to a loop antenna and the laboratory condenser may be used to determine the capacity of small fixed condensers.*



THE CIRCUIT FOR THE EXPERIMENTAL CAPACITY METHOD

FIGURE 3: *This diagram gives the external connections for the condenser to be measured, the loop and the calibrated condenser when connected to an ordinary loop receiver for determining fixed capacities.*

In trouble shooting in a finished receiver it is frequently hard to test a condenser satisfactorily with a dry-cell and phones. There are some faults that may not be detected with this sort of a test. Where a condenser is thought to be either bad or too low in capacity the standard can be substituted and adjusted for the proper value after which a substitution can be made if necessary. Elimination of faulty condensers will remedy a good portion of the experimenter's troubles.

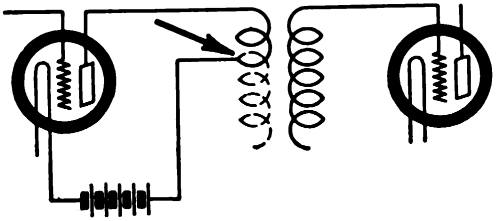
—H. S. KNOWLES

The Prevention of Oscillation and Control of Regeneration In Radio-frequency Sets

HOME-MADE tuned-radio-frequency sets sometimes have a discouraging habit of squealing. This is usually more particularly noticeable at the lower wavelengths (high frequencies). There have been various methods devised to overcome this difficulty.

The simplest method used by the manufacturers of low-priced receivers has been to increase the turn ratio of the coupling coils between the radio-frequency tubes by cutting down the number of turns on the primary or plate windings.

By this method the antenna inductance is usually reduced to four or five turns of wire. The primaries of the radio-frequency coils also consist of a like number of turns. The fewer the number of primary turns the less will be the plate inductance and therefore there will be less tendency towards oscillation or regeneration.

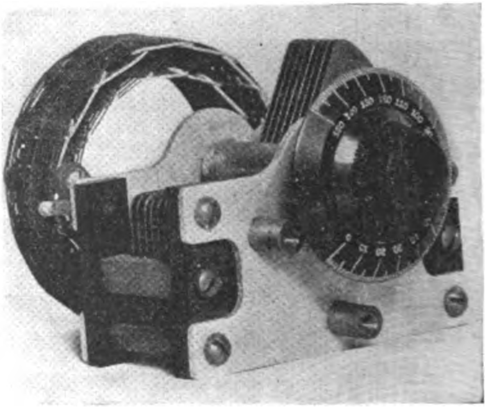


TO PREVENT OSCILLATION

FIGURE 4: *A method for preventing oscillation in a receiver which consists of cutting down the number of primary turns on the radio-frequency transformer. The arrow shows the cut-away primary.*

This method, although it makes the lower wavelengths easy and efficient to tune, will reduce regeneration on the high wavelengths to such an extent that the tuning may be broad and the signals rather weak.

The second method that is used by a number of set manufacturers is to wind the coil with more turns on the primary but to place the coils in close proximity to the metal end-plates of the variable condensers. This causes a loss in the metal end-plate and in the condenser plates themselves, due to eddy currents induced from the windings. The effect of this loss is to prevent oscillation and also reduce regeneration.



TO AVOID SQUEALING

FIGURE 5: *Another method for preventing squealing in a receiver is to place the inductances near the condenser plates, thereby "lossing" the circuit to prevent oscillation.*

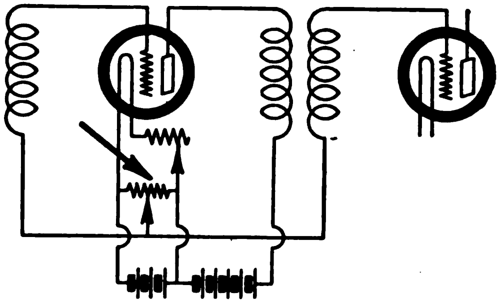
This second method, although it is a simple one and usually produces somewhat louder signals on the higher wavelengths than the first method described, still gives more regeneration and therefore sharper tuning on the lower wavelengths than it does on the higher wavelengths.

The third method which was used to a great extent in the early days of radio-frequency amplification is the use of a grid bias applied through the action of a potentiometer connected across the filament circuit and in series with the grid or input circuits to the tubes.

This method has the advantage that the bias may be increased on the higher wavelengths so that tuning at the higher wavelengths can be made almost as sharp as the lower ones and the volume increased at the same time. However, this method makes the tuned-radio-frequency receiver radiate if not properly handled, and in the ordinary broadcast listener's hands such a set becomes rather a menace. Another trouble with this method is that the amplification obtained by decreasing the bias so that regeneration is prevented or controlled is much less than that obtained by other and better systems.

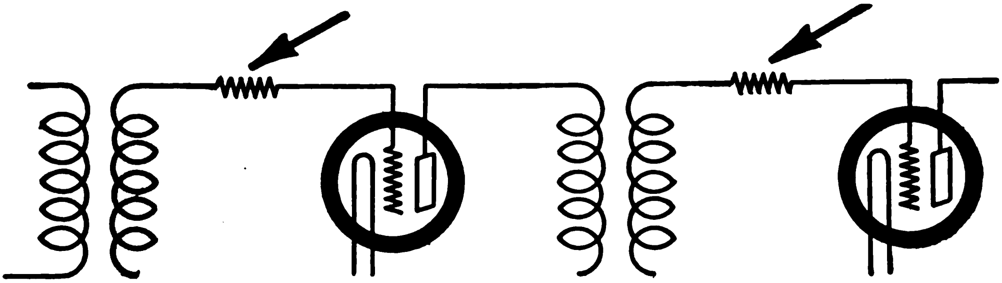
The fourth method—and a practical one—is the insertion of a resistance in the grid circuits of the radio-frequency tubes.

This system does not vary the grid bias but places a load on the grid circuit just enough to prevent oscillation at the low wavelengths. It gives extremely stable operation at all wavelengths and does not materially affect the amplification obtained through the tube. The method consists merely in a load that absorbs the excess energy produced by regeneration.



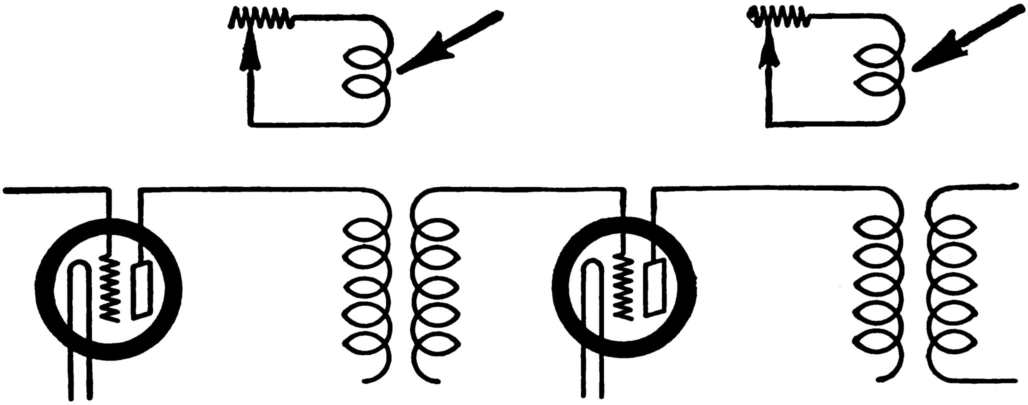
FOR CONTROLLING OSCILLATION

FIGURE 6: *Controlling oscillation in a radio-frequency amplifier by means of a potentiometer for adjusting the grid bias. The arrow points at the potentiometer.*



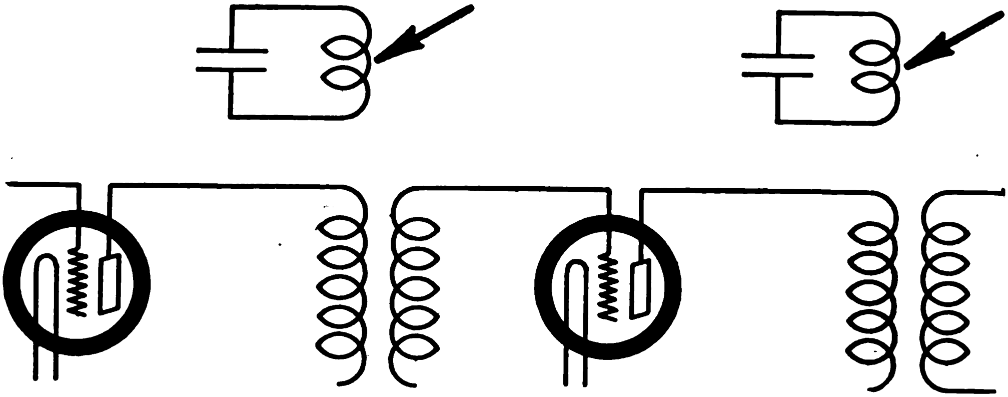
RESISTANCES IN THE GRID CIRCUITS

FIGURE 7: *One other method for preventing oscillation in the radio stages is to insert a critical resistance in series with the grid of the radio-frequency tubes. The extra energy that would cause the circuit to oscillate is absorbed in the resistances, which are indicated by arrows in the diagram.*



A VARIABLE ABSORPTION METHOD FOR PREVENTING OSCILLATION

FIGURE 8: *One or two turns of wire around the primaries and connected in series with a continuously variable rheostat offers exceptionally good control of regeneration in the radio-frequency amplifier.*



THE TUNED ABSORPTION SYSTEM FOR REGENERATION CONTROL

FIGURE 9: *Another absorption method consists of an absorption circuit containing an inductance and fixed capacity which is tuned slightly below the lowest wavelength that the receiver operates on. On the higher wavelengths the circuit of such a receiver is only slightly affected by the absorption circuit, but as the tuning is brought lower and lower, the absorption circuit comes gradually into play, thus preventing oscillation and radiation all the way down the scale. This is the same principle as utilized in the four-circuit tuner.*

The fifth method, which is also an absorption method, may be called the inductive absorption method. It may consist of an inductively-coupled circuit with a condenser in parallel and in inductive relation to the tuning elements of the radio-frequency tubes. It is usually tuned to a low wavelength, and when the receiver is tuned to a high wavelength little absorption is obtained with the circuit. But as the wavelength is reduced in the tuning circuits, the absorption circuit absorbs more and more energy, thus holding down regeneration at the lower wavelengths and making tuning simple and easy. This is an adaptation of the principle of the four-circuit tuner to radio-frequency circuits. It is extremely efficient and a simple method.

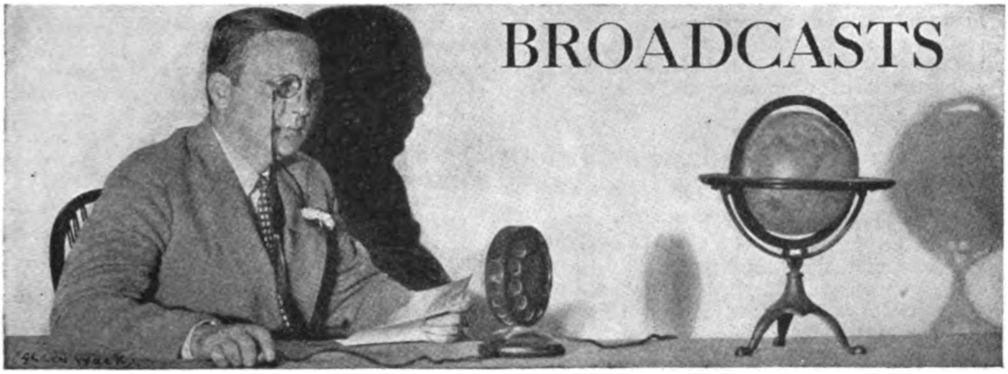
Other absorption methods which come under this heading consist of a single or a number of turns of wire in close inductive relation with the tuning coils which have in series with them a carbon-pile rheostat for controlling the resistance of the circuits and, therefore, the eddy currents that are produced in the inductance loop. This method may be adjusted for any station to increase the amplification and the volume of signals. It is a very simple control and at the same time can be made extremely efficient by critical adjustment.

Neutralization of tube capacity by any of the grid methods, such as the Rice, Hazeltine, Jones or the Scott-Taggart, are usually successful in preventing radiation; the efficiency of a receiver that employs any one of these methods may be increased by slightly upsetting the balance so that regeneration is present to some extent without becoming obnoxious on the lower wavelengths. Perhaps only a single stage may be left unbalanced and thus the selectivity and the distance-getting ability of the receiver may be increased a great many times. This method is very efficient and when once properly adjusted gives very stable operation.

—ROBERT TAIT

Popular Fallacies About Coils

THERE are many misconceptions about the "low loss" feature of coils or inductances. Many of the so-called "low loss" coils that are now so popular among radio fans have less efficiency than some of the older types. Just what constitutes a "low loss" coil and how the characteristics of coils are being studied will be told by D. R. Clemons—in a coming issue of POPULAR RADIO.



CONDUCTED BY J. ANDREW WHITE

IN *this department the Dean of Broadcasters—whose voice is known to millions of broadcast listeners—records items of interest and value to all radio fans everywhere.*

"Radio Home-hunting"

PERCEPTIBLE deepening of the furrows of anxiety in the brows of realtors in the vicinity of Spokane is reported as directly due to an increase of what is termed radio home-hunting. One case is cited wherein it required several weeks and the services of many real estate dealers before a satisfactory location could be found for Frank Stoop, well-known sportsman, who looked over house after house in daylight hours but time after time called off what looked like a sure sale upon returning in the evening with his radio set and finding poor reception in each of the successively selected locations. Stoop finally bought a five-room bungalow (paying more than he originally intended incidentally), which suggests the possibility of premium prices for non-static locations.

* * *

Yankee Apparatus in the East

IT would hardly be thought that more American radio sets and parts are going to the Far Eastern countries than to Europe, but the export figures for this year show that, and also that the Latin-Americans are using almost as much of our stuff as the Canadians did last year. Argentina, Brazil, Mexico, Spain and Australia are of markedly increased importance as purchasers.

* * *

Special Programs for Farmers

TWENTY-ONE stations broadcasting programs developed especially for the farmers is the impressive total reported by the National Farm Radio Council. The subjects comprehended in this service of far-reaching economic importance have been expanded beyond the original schedule of daily market reports to embrace talks on poultry, dairy and livestock subjects, the trend of agricultural developments, marketing of products and even news about meetings of farm organizations. The thoroughness with which the task of supplying these programs is being accomplished is indicated in the Council's announcement that with a string of co-operating stations from the Atlantic to the Pacific programs broadcast from the individual locations are built for the farmers living in the adjacent territory, an analysis of the crops grown in each station serving as the guide to subjects of particular interest in each case.

* * *

A Brindle Cow for a Radio Set

"OF course, we can sell the brindle cow and get another radio," wrote a farmer to KDKA, when that station recently changed its wavelength and could not be received without interference on the set owned by this particular devotee in New Hampshire. Although this man has successfully logged eighty-five other stations, his slogan remains, "Anything to get Pittsburgh." With 571 stations on the air, a neat job is suggested for some tireless investigator—how many are worth the sacrifice of a brindle cow!

* * *

The Meanings of Call Letters

SOMEBODY is always asking the meaning of the initials W and K which precede the call letters of all our broadcasting stations. These initial letters, along with N (used exclusively by the Navy), were assigned to the United States by the International Bureau at Berne to cover all American radio calls except those designating amateur and experimental stations. In the early days, first convenience governed the selection and issuance of station letters, but recently the K calls have been allotted to stations west of the Mississippi and W to those in the eastern section of the country. The letters following the initial K or W serve in many instances as a partial identification of the station's owner, an idea which originated in the helpful spirit of accommodation which the Department of Commerce has always shown toward radio.

* * *

No Radio Bootlegging for John Bull

In a broadcasting controversy centering about the House of Commons recently the principle that the "Englishman's home is his castle" once again emerged triumphant. Beaten down under a storm of protest over a provision granting the right of search for unlicensed receiving sets, Great Britain's wireless bill was withdrawn after it had been properly labeled, "A preposterous piece of bureaucratic tyranny." The bill, it appears, would have empowered Justices of the Peace to search homes where unauthorized apparatus was suspected to be in use, and failure to take out a license carried with it such penalties as imprisonment for a year or a fine not exceeding £500, regulation so severe, one writer insisted, as to make listening-in as dangerous a vice as drug taking or illicit distilling. It is expected that a short substitute bill will be introduced, with a view of establishing the existing license system.

* * *

Communication in Davy Jones' Locker

Commanding officers of two submarines will hereafter be able to hold conversations with their craft submerged, through the development of a new underwater communication system invented by Dr. H. C Hayes, of the Naval Research Laboratory, at Bellevue, D. C. The heterodyne principle is employed in the new invention, thus making possible the reception of high frequencies above audibility of the human ear: heretofore only the comparatively low frequency sound waves could be utilized, which limited under-water communication to the transmission of code messages.

* * *

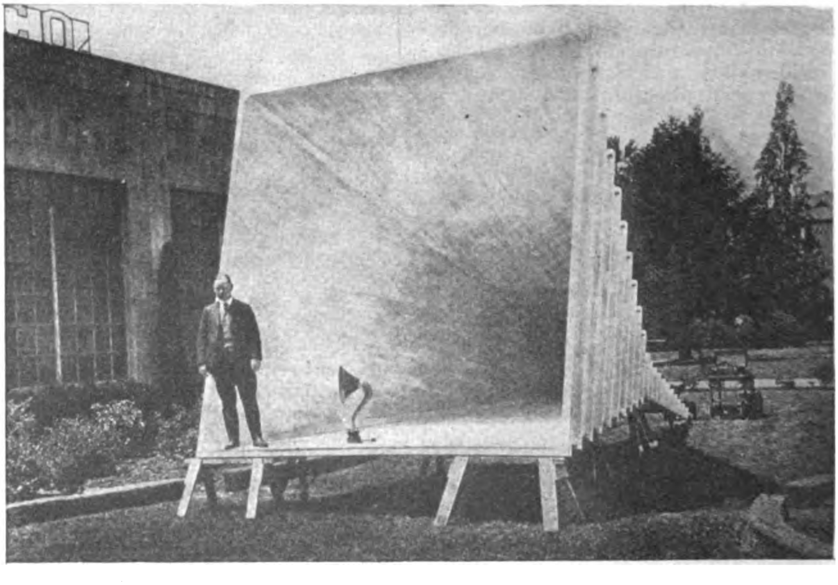
A Novel Radio Fire Alarm

A radio fire alarm system which operates automatically whenever an alarm is turned in at the familiar street corner fire box is a matter of civic pride with the city of Dallas, Tex. The alarm signals, which are not disturbing and are only on the air two or three minutes, are broadcast on a wavelength of 146 meters from equipment which includes a new 50-watt tube transmitter. Firemen off duty in their homes can thus be summoned when required to respond on the occasion of a third alarm, apparatus required from distant parts of the city, too, in the event of a stubborn conflagration is quickly made available, as well as recalls sounded for those en route when no longer needed at the point threatened —these are additional refinements of service reported by Superintendent Garrett, out of four years' experience with the system.

* * *

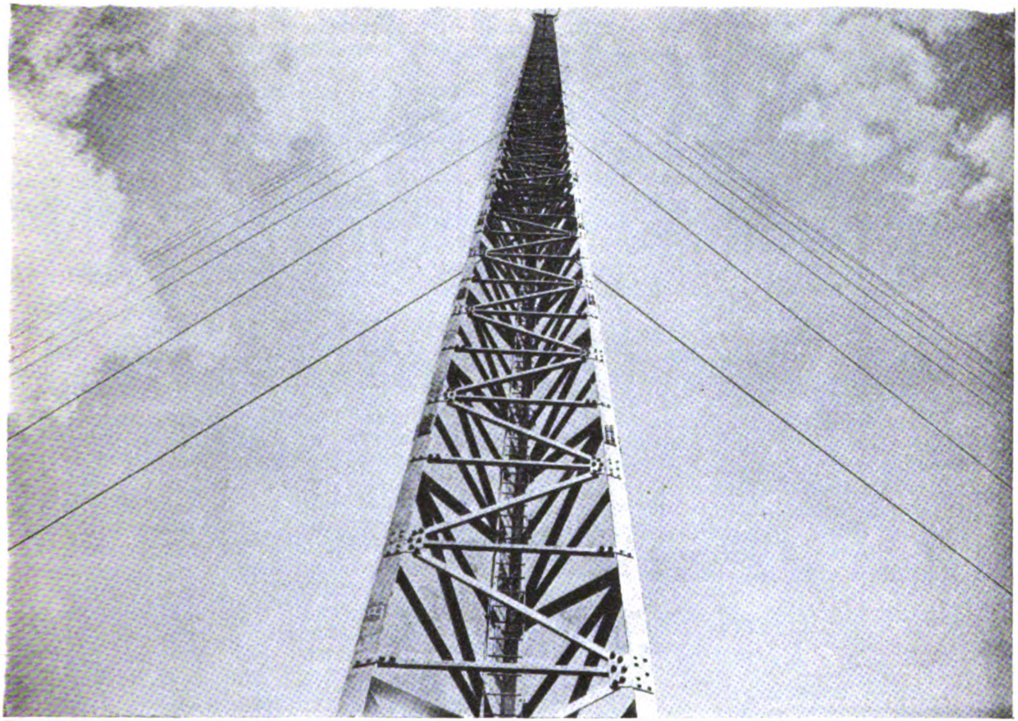
An Amateur Spans 8,000 Miles

Acceptance seems to be quite general of the record claimed by an English amateur in



THE WORLD'S LARGEST LOUDSPEAKER?

An idea that may eventually be carried out in the city parks as well as the village commons throughout the country has found practical expression in Idora Park, San Francisco. This instrument, thirty feet long, has supplanted bands that the park formerly engaged.



Barratts', London

A NEW VOICE JOINS THE ETHEREAL THRONG

One of the newest and most powerful of the English super-power broadcasting stations has just been opened at Daventry; one of the huge antenna masts.

spanning 8,000 miles airline in a twenty minute radiophone conversation carried on a wavelength of 45 meters. Gerald Marcuse, of Caterham, Surrey, accomplished this remarkable feat, talking to Lieutenant Schnell aboard the United States cruiser *Seattle* when the vessel was 600 miles east of Australia. The British Marconi Company's beam station had previously conversed by radio with Australians, but used an extremely high-powered commercial set.

* * *

Dad Is the Real Radio Fan

A LONG standing impression that the youngsters bring radio initially into the house is not borne out in a comprehensive survey made in several sections of the country. The husbands or male heads of the homes were found to be the motivating force in more than half of the cases, and the wife's desire for a receiver came second. Only one set out of every five could be checked up to the credit of the younger members of the family. In seven cases out of ten, too, Dad turned out to be the official manipulator of the dials in supplying the evening's entertainment. Two-thirds of the people interviewed were operating their first set, the others having had two or more receivers previously, but practically all were willing to pay more money for a little better set next time.

Only Local Reception in Brazil

THE retarding effect of unfavorable climatic conditions has achieved for Brazil the trailing position in the development of radio, lagging far behind such South American countries as Chile and Argentina. Static at Rio and in the northern sections of Brazil makes anything but local reception an impossibility during the greater part of the year. In the entire country there are only ten broadcast stations, the extremes of power being represented by 500 watts and 10 watts, and an optimistic estimate of the maximum number of receivers in use would be 12,000. Judging by the number of licenses issued, Brazil has nineteen transmitting amateurs, and long distance reception means little or nothing in the life of the average radio devotee, any fishing for United States stations being practically the exclusive pastime of a few Americans resident in the country.

* * *

Are "Municipal Stations" a Menace?

THE municipal station of New York City, WNYC, ran afoul of the prejudices of some of the residents of the metropolis during the warm months of the year, and city officials found themselves answering in the Supreme

Court charges made by the Citizen's Union that installation and operation of such a station was unconstitutional, and furthermore it was being used to spread "political propaganda." Following which there was much pow-wow with the citizen's body insisting upon an injunction to restrain the station from further broadcasting, and the city officials defending principally on the grounds of the importance of the police alarms sent out twice daily and a scheme for future broadcasting of fire alarms, to say nothing of lectures and musical programs as regular features. The tempest in the teapot subsided when Justice Churchill found that he had insufficient legal grounds for granting the injunction and everything ought to be all right anyhow in the future if the officials would carefully delete those things which seemed to be more for the glorification of the Mayor and his associates than for entertainment and edification of the public. Whereupon New Yorkers sat back and wondered what the station could accomplish that the dozen locals were not doing very well and without any increase in the taxpayer's burden. At last reports they were still wondering.

* * *

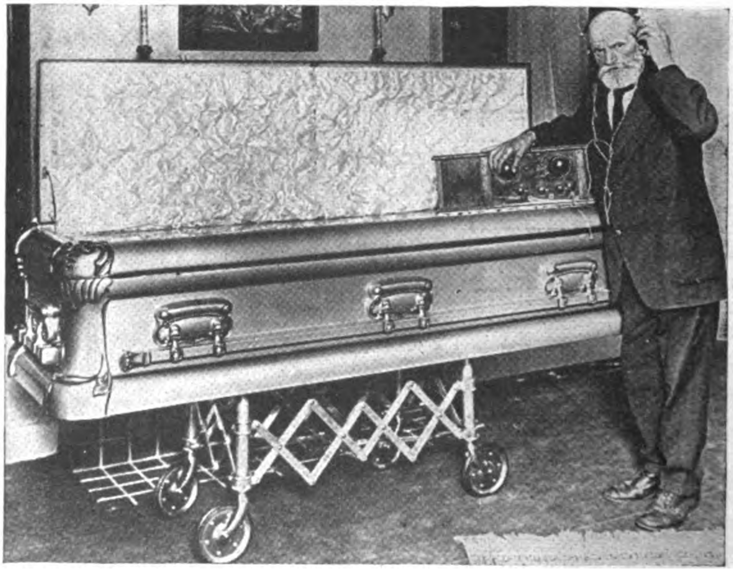
College Laurels for Radio Research

A BIT of radio research was acknowledged the most valuable contribution to the advancement of the college this year, in the award of the Bailey Prize to Edmund B. Redington, of Waverly, N. Y., a senior at Union College. He received a silver loving cup in recognition of undergraduate research work in making a radio transmitter oscillate on the extremely low wavelength of 3.8 meters. Standard equipment was used, employing two 50-watt tubes. The best previous operation had been on four to five meters, dispensing with tube bases and sockets. It had also been deemed essential to nullify the internal tube capacity, but the new oscillator used this capacity rather than an external condenser, an unusually short oscillatory circuit being obtained by the use of extremely short connections between the tube sockets.

* * *

Kipling Takes Up the Broadcasting Problem

THE radio problem in England is engaging the attention of some of Great Britain's most distinguished persons. Among them is Rudyard Kipling, who has agreed to take up radio in a serious way. He accepted an appointment to the committee of ten which will inquire into the future of broadcasting, its control, financing and management in Great Britain. The British Broadcasting Company, consisting of manufacturers of radio apparatus, has a monopoly of broadcasting, but its license will expire in December next year, and the Government committee will draw up a comprehensive plan for governing broadcasting thereafter. The committee includes prominent business men, politicians, educators and one woman, Dame Meriel Talbot, former adviser to the Minister of Agriculture.



Kadel & Herbert

LISTENING IN FROM KINGDOM COME

Sam R. Kimball, an aged San Fernandino Valley rancher, has placed an order with a Los Angeles undertaker for a twelve hundred dollar steel coffin equipped with a radio receiver. Through it he expects to be able to hear what is going on in the world after he dies, being convinced, he says, that the soul lingers near the body until the day of judgment.

Engineering
Lib

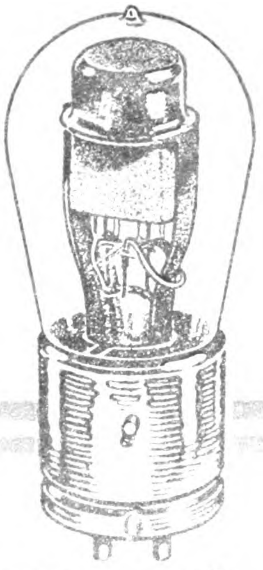
Popular Radio

with which is combined The Wireless Age

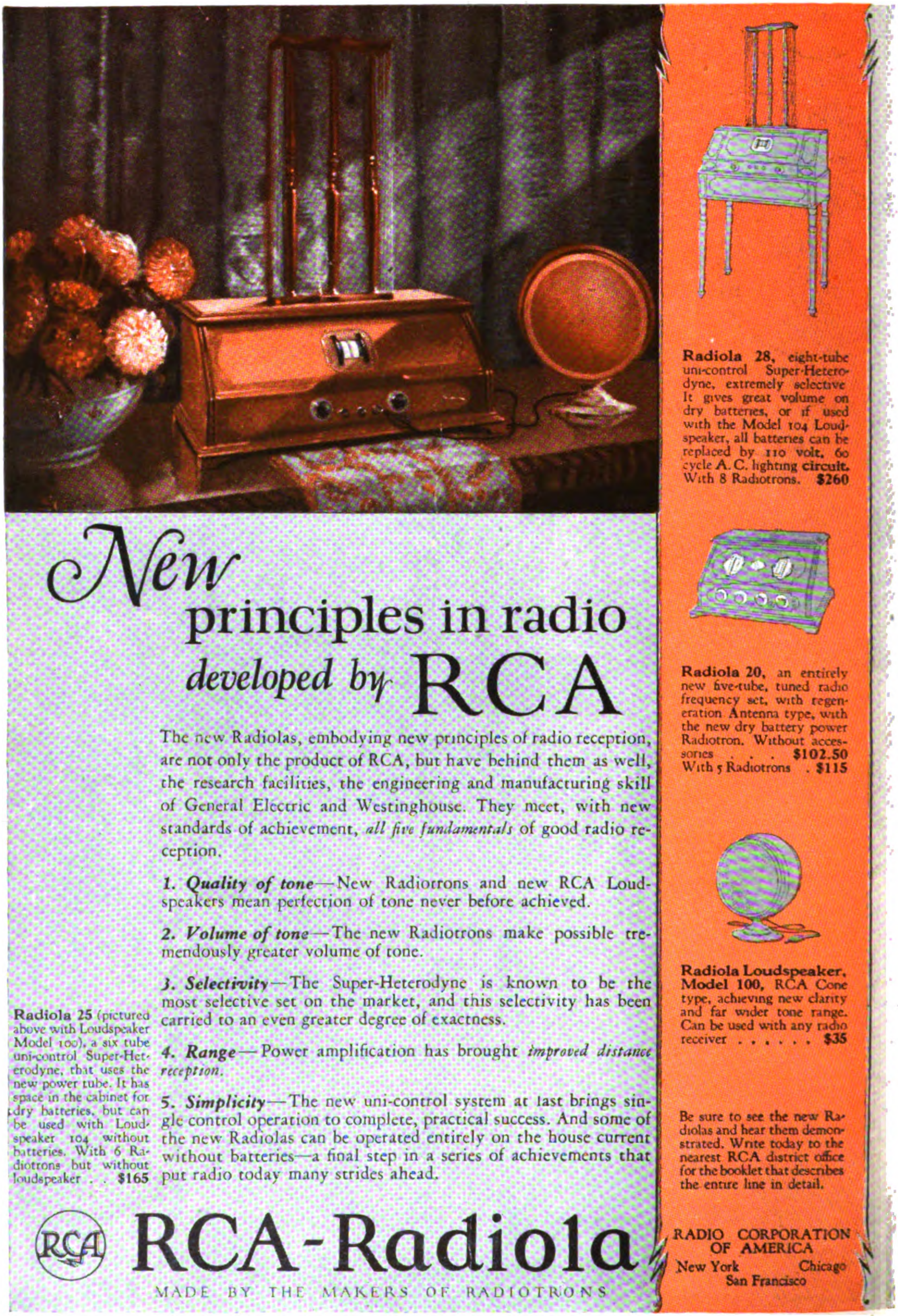
Edited by KENDALL BANNING

25¢

NOVEMBER
1925



How to Build the Raytheon Plate Supply Unit



New principles in radio *developed by* RCA

The new Radiolas, embodying new principles of radio reception, are not only the product of RCA, but have behind them as well, the research facilities, the engineering and manufacturing skill of General Electric and Westinghouse. They meet, with new standards of achievement, *all five fundamentals* of good radio reception.

1. ***Quality of tone***—New Radiotrons and new RCA Loudspeakers mean perfection of tone never before achieved.

2. ***Volume of tone***—The new Radiotrons make possible tremendously greater volume of tone.

3. ***Selectivity***—The Super-Heterodyne is known to be the most selective set on the market, and this selectivity has been carried to an even greater degree of exactness.

4. ***Range***—Power amplification has brought *improved distance reception.*

5. ***Simplicity***—The new uni-control system at last brings single control operation to complete, practical success. And some of the new Radiolas can be operated entirely on the house current without batteries—a final step in a series of achievements that put radio today many strides ahead.

Radiola 25 (pictured above with Loudspeaker Model 100), a six tube uni-control Super-Heterodyne, that uses the new power tube. It has space in the cabinet for dry batteries, but can be used with Loudspeaker 104 without batteries. With 6 Radiotrons but without loudspeaker . . $165

Radiola 28, eight-tube uni-control Super-Heterodyne, extremely selective It gives great volume on dry batteries, or if used with the Model 104 Loudspeaker, all batteries can be replaced by 110 volt, 60 cycle A. C. lighting circuit. With 8 Radiotrons. **$260**

Radiola 20, an entirely new five-tube, tuned radio frequency set, with regeneration Antenna type, with the new dry battery power Radiotron. Without accessories . . . **$102.50**
With 5 Radiotrons . **$115**

Radiola Loudspeaker, Model 100, RCA Cone type, achieving new clarity and far wider tone range. Can be used with any radio receiver **$35**

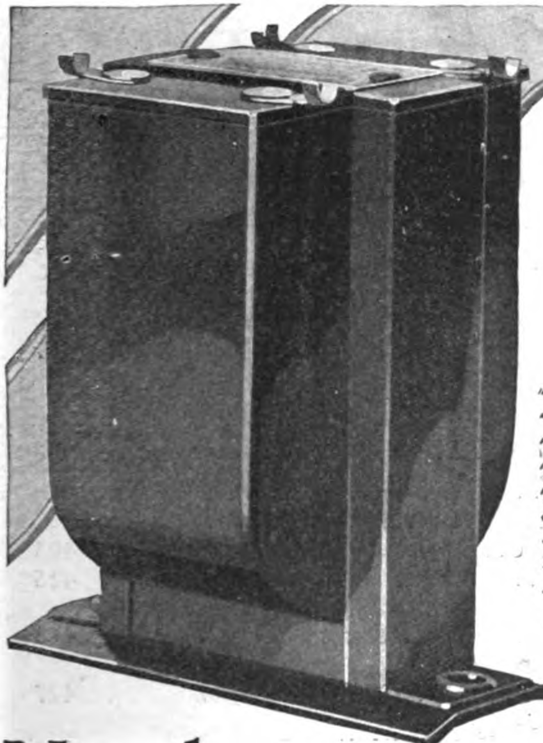
Be sure to see the new Radiolas and hear them demonstrated. Write today to the nearest RCA district office for the booklet that describes the entire line in detail.

RCA

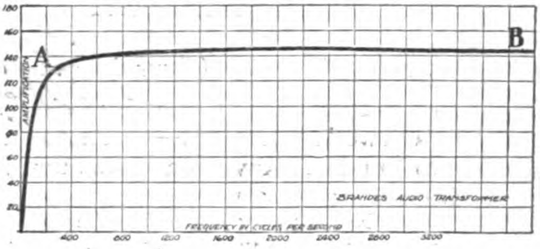
RCA-Radiola

MADE BY THE MAKERS OF RADIOTRONS

RADIO CORPORATION OF AMERICA
New York Chicago
San Francisco



This diagram shows the amplification curve of the new audio transformer. (A) shows the high amplification of the low tones. Straight line from (A) to (B) shows uniform amplification over the whole range.



Price $4^{00}

New low tones—new high tones with a Brandes Transformer

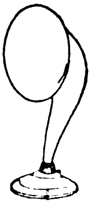
HERE'S a new audio transformer that "lets through" the deep and the high tones—that gives an *even* amplification over the whole range.

It amplifies at a high ratio of 1 to 5—without any transformer distortion. And its perfect amplification of the overtones gives mellowness and reality.

Address, 200 Mt. Pleasant Ave., Newark, N.J., for an interesting booklet describing Acoustics by Brandes.

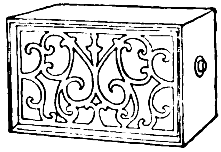
Prices slightly more west of the Rockies and in Canada

The Type H—a horn of graceful lines and antique green and black finish. Great in volume—true in tone. Adjustable . $18



The Brandes Cabinet Speaker of mahogany, finished in walnut brown. The same unit, quality of tone and even greater volume than the Type H $30 *(pictured below).*

The Brandes Cone—a truly decorative bit of furniture that conceals a remarkable speaker $38 *(pictured above).*



Brandes

EXPERTS IN RADIO ACOUSTICS SINCE 1908

POPULAR RADIO

WITH WHICH IS COMBINED "THE WIRELESS AGE"

EDITED *by* KENDALL BANNING

FOUNDED 1911

CONTENTS *for* NOVEMBER, 1925

(*Cover design by Frank B. Masters*)

VOLUME VIII NUMBER 5

Radio Apparatus Sorts Cigars by Color .... FRONTISPIECE

Radio's Newest Instrument—the Photo-electric Cell . . *E. E. Free* .... *Page* 397

How to Build the Raytheon Plate Supply Unit ..... *Laurence M. Cockaday* .. 405

A Measurement Chart .... *Raoul J. Hoffman* 415

No. 12: For Estimating the Inductance of a Single-layer Coil

New Methods of Calibrating Your Receiver .... *Morris S. Strock* 418

How to Get the Most Out of Your Ready-made Receiver .... *S. Gordon Taylor* 427

No. 9: The Garod Neutrodyne Type V Receiver

The Atom .... *William Bragg* 438

Article No. 3: The Nature of Liquids

Handy Tools for Radio Fans .... *The Technical Staff* 443

No. 8: The Socket-Wrench

Practical Pointers About Transformers .... *F. E. Nimmcke* 444

Multi-layer Coils .... *Oliver Lodge* 453

Simple "How-to-build" Articles for Beginners ...... *Laurence M. Cockaday* .. 456

No. 13: How to Build a Single-stage Impedance-coupled Amplifier

DEPARTMENTS

In the World's Laboratories .... *E. E. Free* 460

What Readers Ask .... *Hugh S. Knowles* 468

The Broadcast Listener .... *Raymond Francis Yates* . 472

In the Experimenter's Laboratory .... *Laurence M. Cockaday* .. 476

What's New in Radio Apparatus .... *The Technical Staff* 486

With the Inventors .... *William G. H. Finch* 488

VOLUME VIII NOVEMBER, 1925 NUMBER 5

Published monthly by Popular Radio, Inc., 627 West 43rd St., New York, N. Y., telephone number, Chickering 1906; Douglas H. Cooke, President and Treasurer; Kendall Banning, Vice-President; Laurence M. Cockaday, Secretary; Joseph T. Cooney, Asst. Treasurer. Price 25 cents a copy; subscription $3.00 a year in the U. S., Canada and all countries within the domestic postal zone; elsewhere $3.50 a year, payable in advance. The International News Company, Ltd., No. 5 Bream's Bldg., London, E. C. 4, sole distributors in England. Entered as second class matter April 7, 1922, at the Post Office at New York, N. Y., under the act of March 3, 1879.

Copyright, 1925, and title registered as a trade-mark by Popular Radio, Inc. Copyright in Great Britain by Popular Radio, Inc. 6 Henrietta St., Covent Garden, W. C., London, England.

Printed in U. S. A.

LAURENCE M. COCKADAY, *Technical Editor*

E. E. FREE, Ph.D., *Contributing Editor* JOHN V. L. HOGAN, *Contributing Editor*

For advertising rates address

E. R. CROWE & COMPANY, INC.

New York: 25 Vanderbilt Avenue Chicago: 225 North Michigan Avenue

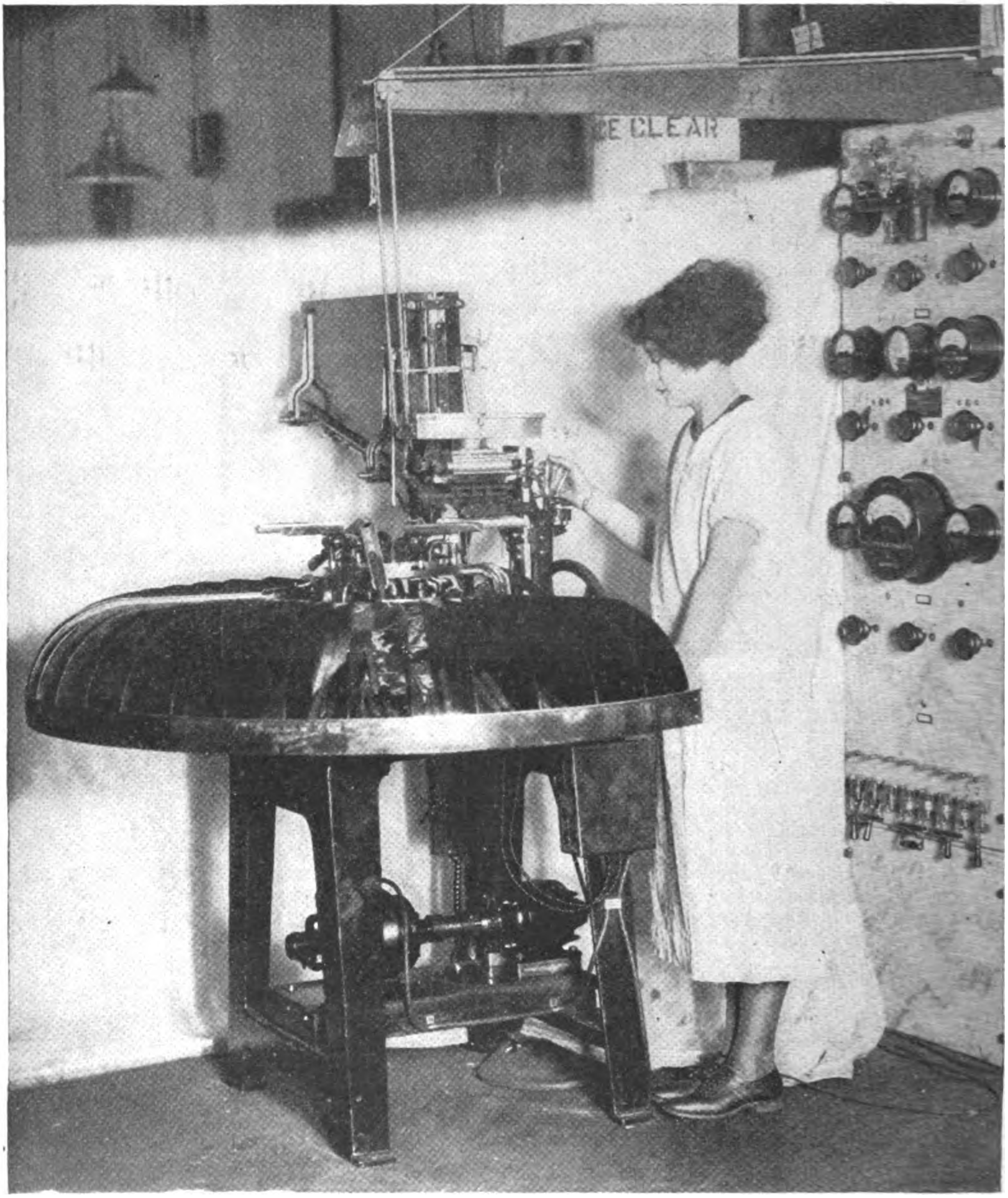
Wide World

The High Place Occupied by POPULAR RADIO in the Radio Profession

"I WISH *to congratulate you on the work that* POPULAR RADIO *has been doing. You have balanced the subject matter of the magazine remarkably well, maintaining a very dignified and reliable scientific background, yet making it readable and of popular interest to the public. From personal experience I know the skill which this involves. I wish to congratulate you also for the high place that your magazine has taken in the estimation of the radio profession.*"

John Hays Hammond Jr.

PRESIDENT, HAMMOND RADIO
RESEARCH LABORATORY



American Machine and Foundry Co.

Radio Apparatus Sorts Cigars by Color

THE *remarkable photo-electric cells, now coming rapidly into use in radio, especially for the broadcasting and reception of pictures, have been made to do the work of the human eye in selecting the lighter, the darker and the redder varieties of cigars. A beam of light is reflected from the cigar into a photo-electric cell. This operates a relay which sorts the cigars into differently colored groups.*

Popular Radio

WITH WHICH IS COMBINED "THE WIRELESS AGE"

VOLUME VIII NOVEMBER, 1925 NUMBER 5

RADIO'S NEWEST INSTRUMENT—

The Photo-electric Cell

In all the marvelous development of radio, one new device is essential—the photo-electric cell. This article describes how photo-electric cells are built and how our familiar friends, the electrons, operate them, much as they do the ordinary vacuum tubes of radio.

By E. E. FREE

THE rise of modern radio began with the perfection of the vacuum tube—one of the most remarkable and useful instruments ever devised by science, and the first one, with the exception of a few laboratory devices, in which free electrons were put to work for a useful purpose. The entire radio industry would collapse overnight if those tiny electrons which fly off from the hot filaments of our vacuum tubes went on strike and refused to behave any longer in the manner which we have grown so confidently to expect.

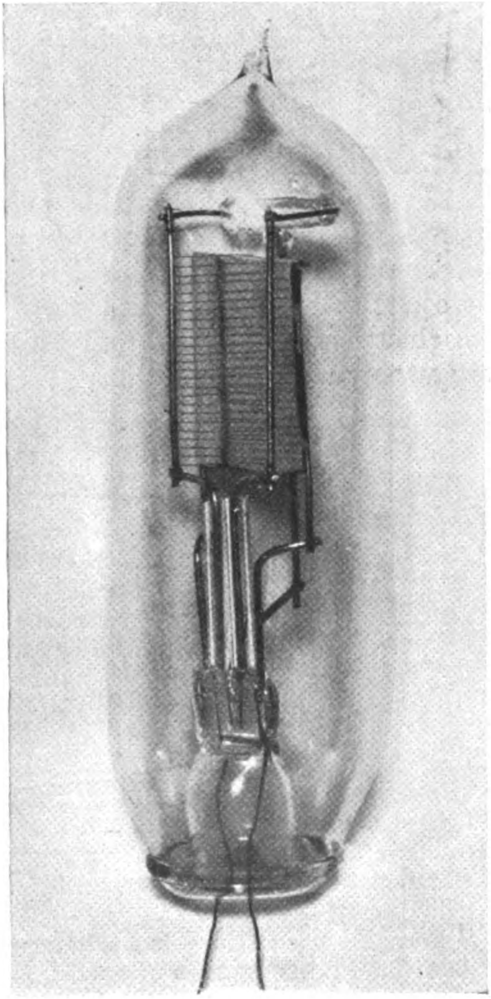
Now another electron device is beginning to find uses in radio as well as in other industries. It, too, is a vacuum tube, although constructed and operated quite differently from the familiar detectors and amplifiers used in radio.

It is called a photo-electric cell.

What the photo-electric cell does is to convert a light beam into a stream of electrons. Or, to speak more exactly, the light beam which enters the cell starts off a stream of electrons, much as the heat of the filament of an ordinary radio vacuum tube starts the electrons to streaming from it and across to the plate. By means of photo-electric cells, arranged with various other devices and accessories, it is possible to convert a light signal into an electric signal, or even to convert into audible sounds a regular vibration which has been carried by the light beam.

Photo-electric cells are in use in nearly all of the modern systems of sending pictures by wire or by radio.

These cells serve to convert the alternations of the light which constitute the picture into electric alternations which can be sent over the wire or superposed on an outgoing carrier wave. Similarly, photo-electric cells serve to translate the photographic record of the talking moving picture back into electric oscillations, which may then be converted once more into audible sound. Again, the photo-electric cell is one of the very few relay devices which has practically no lag and no inertia. Finally, it is being applied rapidly to the measurement of the intensity and quality of light.



From a photograph made for POPULAR RADIO

INSIDE A PHOTO-ELECTRIC CELL

This blank, into which the alkali metal has not yet been introduced, indicates the assembly of the parts shown in illustrations on following pages.

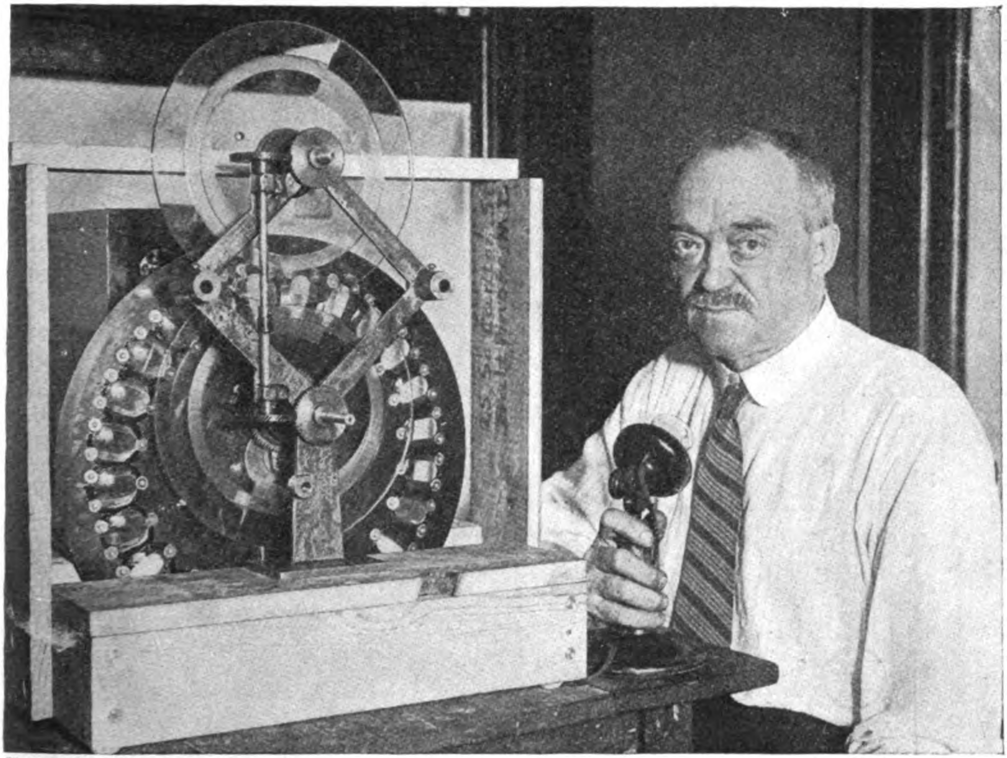
The basic principle on which the photo-electric cell operates was discovered long ago by the German physicist, Hallwachs, and is simple. It is merely that certain metals have the property of giving off electrons when the surface of the metal is illuminated.

Under ordinary conditions, with the surface of the metal exposed to the air, this emission of electrons is imperceptible. The electrons are lost in the vast swarm of air atoms which surround the metal.

But if the metal is put in a vacuum and if a beam of light is then allowed to fall on it, the electrons are not stopped by the air atoms. They become quite perceptible. If some kind of a grid or plate or other collector is put in the vacuum with the illuminated metal plate, the electrons may be collected on this and will give a quite measurable "plate current," just as do the electrons which are driven off by heat from the filament of an ordinary vacuum tube. The electrons will continue to be given off and the current due to them will continue to flow so long as the beam of light continues to fall on the metal plate.

Just as a dynamo is a machine for converting mechanical motion into electricity and as a telephone is a device for converting electric vibrations into the vibrations of sound, so the photo-electric cell is an energy converter of another kind. It converts a part of the energy of light into electricity; that is, into free electrons. At present the best photo-electric cells make this conversion of light energy into electric energy only very inefficiently. Most of the energy of the light goes to waste. But even the dynamo is not a perfect converter of one kind of energy into another, and it was still less perfect in its early days when it had just been invented. It has been improved. Possibly the photo-electric cell will be improved no less.

If it can be, there are some interesting possibilities. One of them is the utilization of sunlight. It is sunlight which



Henry Miller

PHOTO-ELECTRIC CELLS ARE USED TO BROADCAST MOVING PICTURES

This famous apparatus (already described in POPULAR RADIO), *is employed by Mr. C. Francis Jenkins, of Washington, D. C., to send moving pictures by radio. Photo-electric cells are used at the transmitting end, in order to translate the variations of light and shade into electric vibrations which are then sent out as modulations on the radio wave.*

keeps the world alive. Solar energy raises the water from the sea to make the rain, it provides the power that drives the winds, it gives living plants the energy which they need to produce sugar and starch and fodder and wood. The total amount of sunlight and solar heat which falls on the earth is equivalent in heat value to the burning of 100,000,000 tons of coal *each minute* for ever and ever.

If we could but catch and use a small fraction of this power—if we possessed, for example, a really efficient photo-electric cell, which would convert eighty or ninety percent of this solar energy into electricity—we would not need to worry any more about the exhaustion of the coal mines. Energy would be about the cheapest thing in the world.

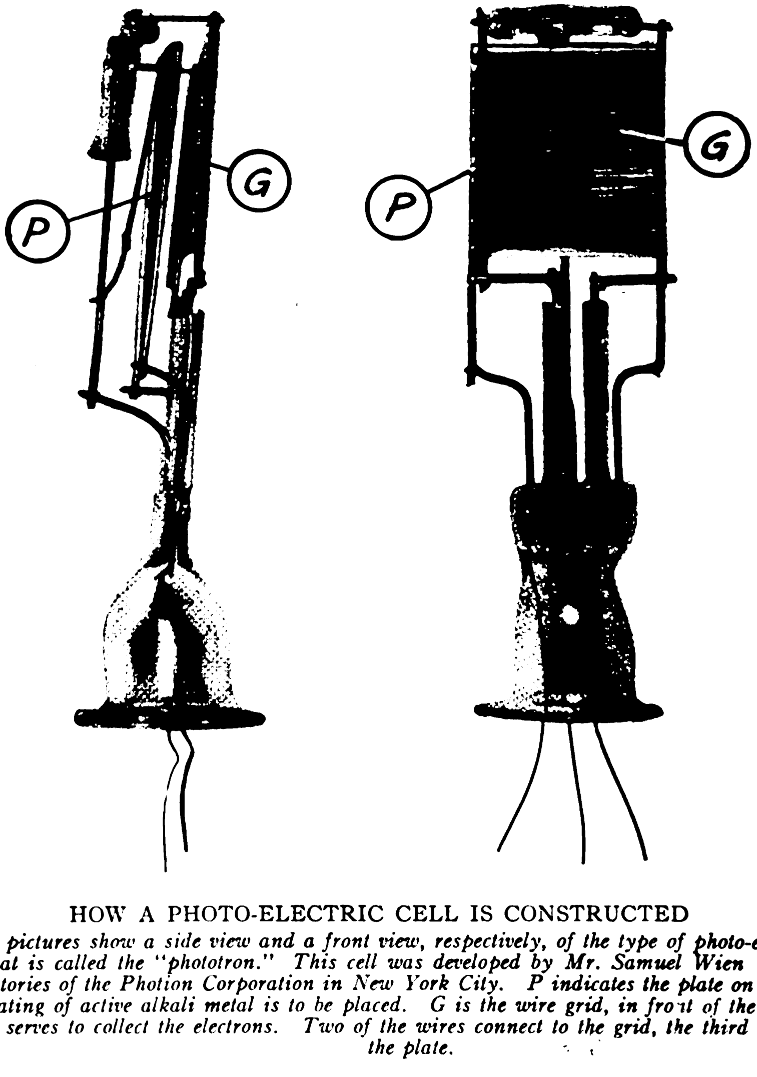
Unfortunately, no such boon is in sight. Even with the most efficient and modern types of photo-electric cell a beam of full sunlight falling on the cell will free only enough electrons to produce a minute fraction of an ampere. The device is now, and probably will be for some time, a way of detecting light *signals* rather than a way of making practical use of the energy in the light.

This is so because the action of the photo-electric cell is essentially an atomic action and one in which only a small fraction of the atoms of the active metal are taking part at any one instant. Most of the modern photo-electric cells use, as the active metal, one of the so-called "alkali" metals, potassium, sodium, lithium, caesium or rubidium.

All of these metals have atoms possessing, we believe, the same significant characteristic. One of the electrons of each atom is relatively far away from the center of the atom and is attached relatively loosely to it. It is as though our solar system had a number of planets close in to the sun and firmly held to it, while one lonely planet was away off in space, far outside the others and likely to be detached rather easily from the rest of the group.

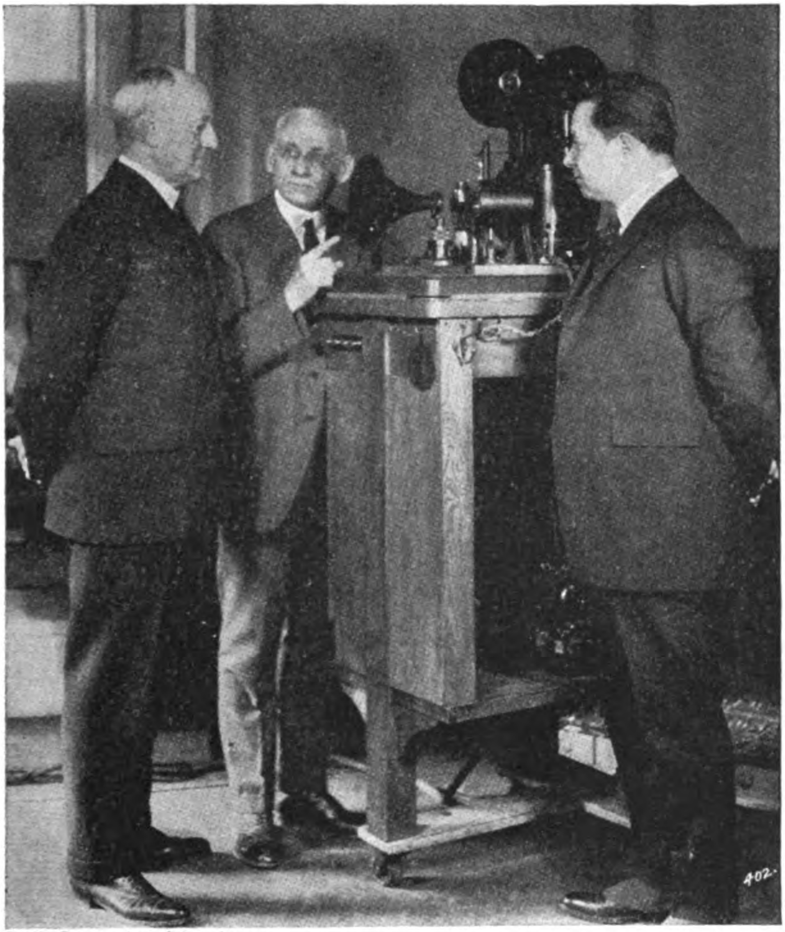
It is probably these outer, loosely bound electrons of the atoms in the plate of potassium which are detached by the light rays and which are responsible for the photo-electric effect.

So much has been written lately about the nature of atoms and the relations of electrons to them that everyone interested in radio has a general idea of what they are like. Our potassium plate, for example, is not really smooth and solid, as it seems to be. It is really a rather open network of atoms, held near each other by their mutual electric and magnetic attractions. Around the central body or "nucleus" of each atom there revolve a number of electrons, behaving



HOW A PHOTO-ELECTRIC CELL IS CONSTRUCTED

These pictures show a side view and a front view, respectively, of the type of photo-electric cell that is called the "phototron." This cell was developed by Mr. Samuel Wien in the laboratories of the Photion Corporation in New York City. P indicates the plate on which the coating of active alkali metal is to be placed. G is the wire grid, in front of the plate, which serves to collect the electrons. Two of the wires connect to the grid, the third one to the plate.



Radio Corporation of America

ANOTHER INVENTOR WHO USES PHOTO-ELECTRIC CELLS

In the center is Mr. C. A. Hoxie, of the General Electric Company, demonstrating his apparatus for making sound records on a motion picture film. General Harbord, of the Radio Corporation of America, is at the left, and Mr. Sarnoff at the right. Mr. Hoxie's invention makes use of a photo-electric cell to re-translate the photographic record into electric vibrations and thence into sound.

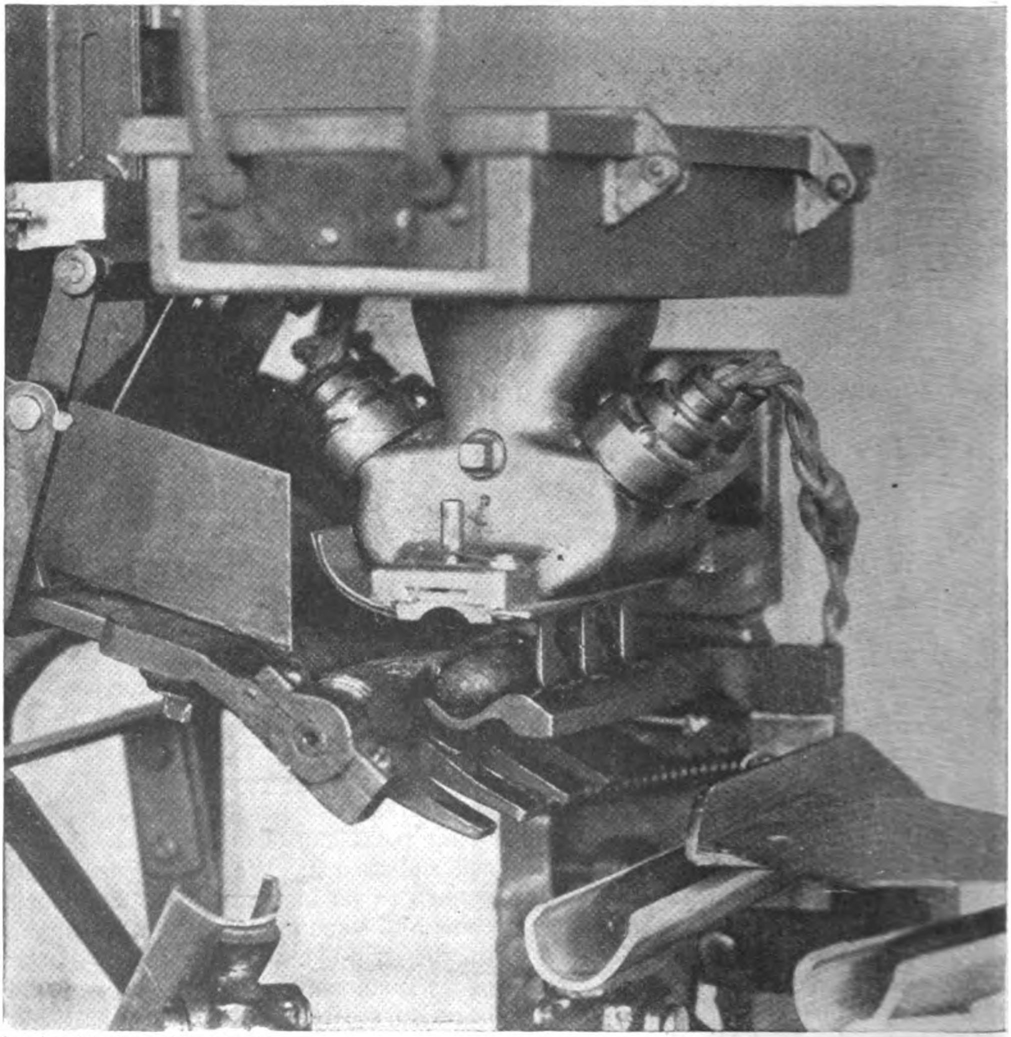
much as do the planets which surround our sun, except that the electron planets revolve in many different planes, not close to one plane as do the astronomic planets. In the atom of potassium there are nineteen of these planetary electrons.

The size of these atoms and electrons is, of course, astoundingly minute. In that famous classic, "Alice in Wonderland," the fortunate Alice chanced to find, you remember, some magic medicines which made her shrink or swell at will. Suppose we had some of the shrinker and suppose we stood in front of the potassium plate of a photo-electric cell and used it. We would grow small enough to get inside the cell; then small enough to stand quite comfortably on one of the grid-like wires in front of the plate; small enough, finally, that we could begin to see the tiny atomic nuclei and the flying electrons surrounding them.

When we got to this point we would be so small that it would take about a billion of us, laid end to end, to make an inch. The entire population of the world could come in with us into the photo-electric cell and still leave plenty of room for some new arrivals from Mars.

To put it another way, if you were as small as that and if you walked off across the potassium plate at a speed corresponding to a swift walk of an ordinary-sized man, it would take you nearly forty years, walking continuously day and night, to walk one inch.

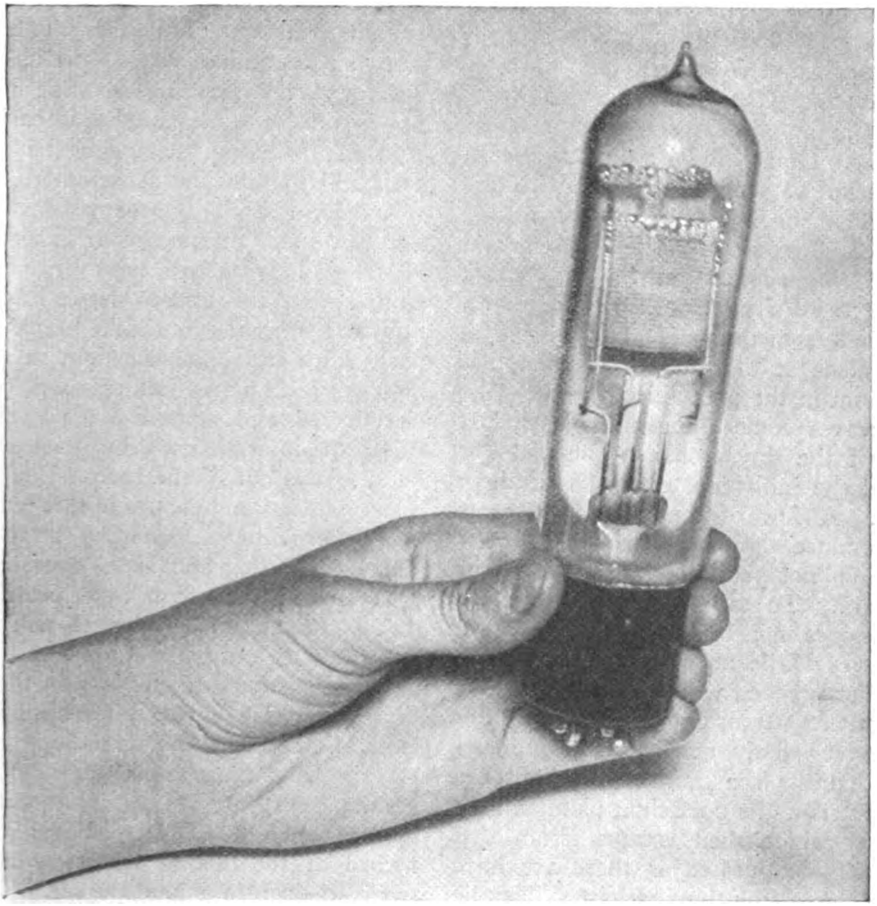
Small as you would be, the electrons driven off from the potassium by the light beam would be much smaller still. They would look like grains of dust. As you stood close to the surface of the metal one of these dust grains would get loose once in a while from the atom to which it had been attached and would whiz past you. This would happen very seldom indeed, in comparison with the number of atoms present. Even in a very strong light, only one electron out



American Machine and Foundry Co.

THE PHOTO-ELECTRIC EYE OF THE CIGAR SORTING MACHINE

This is a part of the machine shown entire in the frontispiece of this issue. The cigar is seen resting in the little trough in the center. In the box above is a photo-electric cell which receives light reflection from the cigar. Different colors reflect different amounts and quantities of light, so that the cell can distinguish them automatically.



From a photograph made for POPULAR RADIO

A MODERN PHOTO-ELECTRIC CELL COMPLETE

This is the finished phototron, the internal parts of which have been shown in preceding illustrations. Note the droplets of congealed potassium clinging to the supports and to the upper edge of the plate. A thin coating of this metal covers the surface of the plate and forms the active material for the detection of any light ray entering from the front of the cell and passing through the wires of the grid. This cell is equipped with a standard radio base.

of many million atoms is detached each minute by the photo-electric action. The reason why the action is perceptible at all is simply that so many billions of billions of atoms are present in even the tiniest plate of potassium.

Why the light drives out an occasional electron in this way from the assemblage of potassium atoms is one of the things that the physicists still do not know. It is well known, of course, that atoms can lose electrons in a number of ways.

Suppose, for example, that a lot of atoms of potassium are flying around freely in a heated space, forming a potassium gas. The atoms will hit against one another frequently, just as sand grains do in a dust storm. Some of these collisions of one atom with another will be quite forcible; even more forcible, in proportion to size, than the collision of two high-speed express trains. It has been proved that such collisions occasionally knock off the loosely-bound outer electron, leaving the potassium atom minus one electron. It then possesses one unbalanced unit of positive electric charge, a unit which was previously neutralized by the electron which has disappeared. This positively charged potassium atom is called an "ion."

Other things besides atomic collisions can make an atom lose an electron in this way. One of them is light. An intense beam of ordinary light or of ultra-violet light or of X rays, sent into a mass of gaseous potassium atoms will produce some ionization. It will knock out electrons from some of the atoms. Doubtless something of this same sort takes place at the surface of the solid potassium in the photo-electric cell. The light waves come along and hit against some of the tiny atoms in the plate or against the individual electrons of these atoms. A few of the electrons fly off and produce the photo-electric effect.

We do not yet know just what light rays are. To say that they are ether waves does not help us much, for we know very little about the properties of the ether or even whether there really is any ether. Accordingly, we can only guess, very dimly, at what kind of interaction takes place between the light ray which strikes the potassium plate and the electron which then escapes from that plate. Such guesses as there are have great interest for the physicist. They lie close, for example, to the present puzzles of the quantum theory of light and to certain aspects of the famous Einstein theory of relativity. But they are not, at present at least, of much practical assistance in radio or in the understanding of photo-electric cells.

For practical purposes what one needs to remember is this. When light hits against a plate of potassium or of certain other metals in a vacuum, electrons are given off from this plate. Within limits, the number of electrons thus given off per second is proportional to the intensity of the light. A grid, or some other device, opposite to the illuminated plate is kept at a high positive potential relative to the plate. The electrons immediately seek this grid. They may be returned to the plate through a galvanometer, which measures their number. This is the photo-electric current of the cell. It is proportional to the intensity of the light.

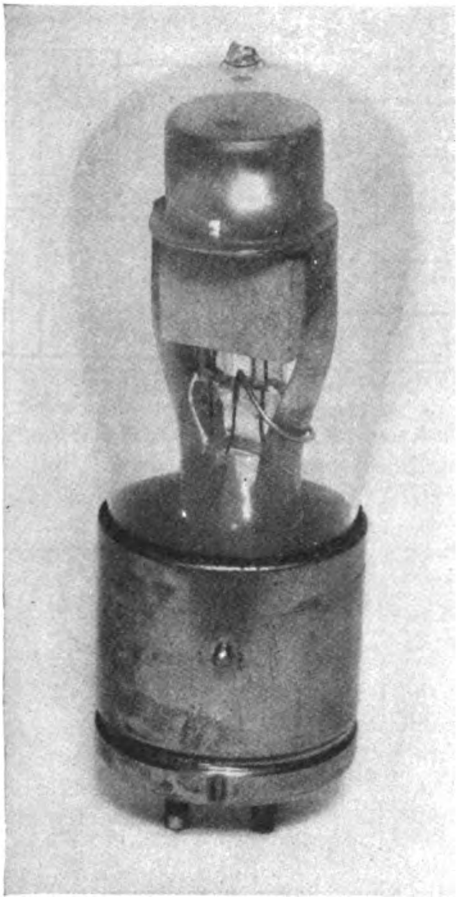
One of the practical uses of photo-electric cells is to measure the intensity of light in this way. Starlight has been measured thus by the astronomers. Botanists have used the same device to measure the light needed by plants.

More frequently, however, photo-electric cells are used to detect interruptions or variations in a light beam. Suppose, for example, that a light ray from an electric lamp is falling on a photo-electric cell, and suppose that you cut off this light intermittently by placing your hand in and out of the beam. You could telegraph dots and dashes in this way; indeed the military signalling instrument called the heliograph is so operated.

If this dot-and-dash light beam falls on a photo-electric cell the cell will translate the dots and dashes into electric signals. Variations of intensity in the light beam, without entire interruption, are similarly recorded by variations in the current from the photo-electric cell. The resultant currents can be amplified to any desired strength. Thus the varying light-record of the talking moving picture is made to operate a loudspeaker. Thus a code message may be telegraphed along a light beam. Thus the light of a star will make its own record of the instant at which it passes the cross-wires of a telescope, to mark the standard time.

It is quite possible, even, that everything which we see is due to a photo-electric effect. Light which falls on our eye produces, we know, a change of some kind in the sensitive retina at the back of the eyeball. Many physiologists believe that this change is a photo-electric change; that some constituent of the retina loses electrons under the influence of light, just as does the potassium plate of the photo-electric cell.

The eye may be a living photo-electric cell. Turning the argument around, a photo-electric cell may serve, quite successfully, as a radio eye.



THE RECTIFIER TUBE

Figure 1: *The Raytheon tube which makes possible this new device is a filamentless tube of the famous "S" type. But it has been developed so that a single tube utilizes both halves of the alternating current for rectification.*

HOW TO BUILD THE

Raytheon Plate Supply Unit

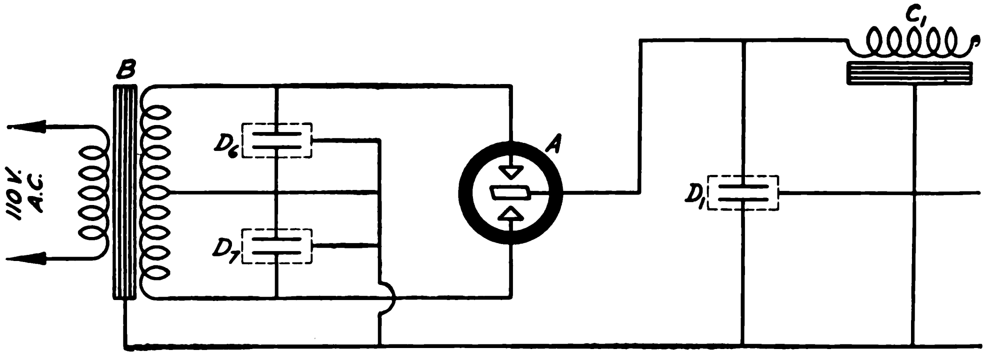
For years the radio world has been waiting for a really dependable method for obtaining a "B" source of supply from the electric light wires in our homes. This article describes the new unit that is the first to solve this problem.

By LAURENCE M. COCKADAY

Cost of Parts: *Not more than* $45.00

Here Are the Items You Will Need—

A—Raytheon tube;
B—Acme Apparatus Company transformer for Raytheon plate-supply unit, type No. B-4; (See note on page 414)
C1 and C2—Acme Apparatus Company 30 henry choke coils for Raytheon plate-supply unit, type No. B-2; (See note on page 414)
D1 and D2—Tobe shielded, high-voltage paper condensers, 2 mfd.;
D3 and D4—Tobe shielded, high-voltage paper condensers, 4 mfd.;
D5—Tobe shielded, high-voltage paper condenser, 1 mfd.;
D6 and D7—Tobe shielded, high-voltage paper condensers, .1 mfd.;
E—Federal socket, type No. 16;



THE COMPLETE CIRCUIT DIAGRAM

FIGURE 2: *The hook-up for the plate supply unit. All the symbols for the instruments bear designating letters, which are used consistently in the list of parts, text and illustrations.*

F—Benjamin cleat receptacle, type No. 9401;
G—Bradleyohm No. 10, 100,000 ohms;
H—Bradleyunit resistance, 7,500 ohms;
I—Electrad resistance mounting;
J—hardwood baseboard, 7 by 20 inches;
K—composition binding post strip, 1 inch by 7 inches;
L—small brass brackets (see Figure 9).

THE development of so-called "B" eliminators during the past two years has been rapid. During that time there has been a great amount of experimentation in an endeavor to obtain a really satisfactory method for employing the alternating current as an energy supply for the plate circuits of vacuum-tube receivers. During this time there have also been some hundreds of such allied schemes made public for accomplishing this end—some of them very successful and some of them not at all so.

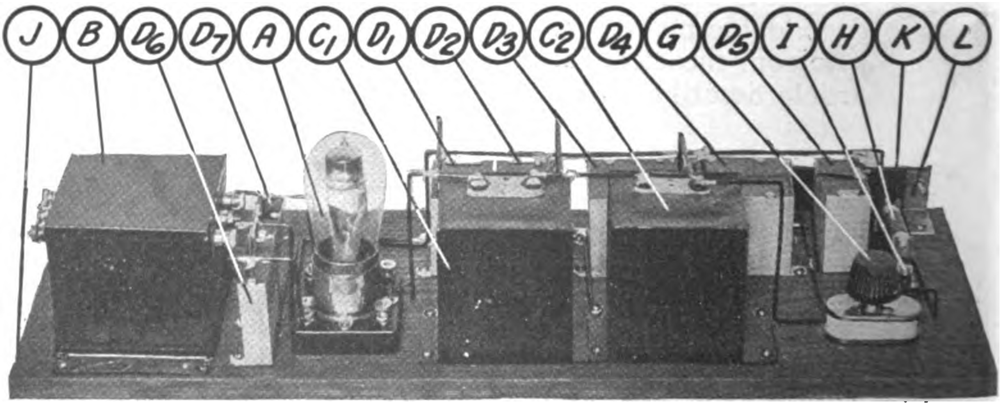
Heretofore the two main drawbacks to such a device have been:

First: the inability to filter out all hum;

Second: the short life of the rectifier tubes.

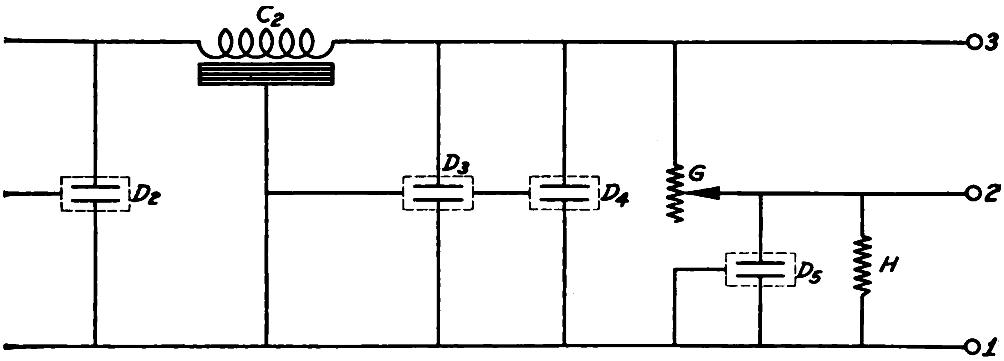
Of course, this second consideration applies only to plate-supply units that employ vacuum tubes as rectifiers.

It is well known that the UV-201-a tube when used as a rectifier may be easily overloaded when employed in connection with a set that employs five tubes or more. This is especially true when the receiver uses no "C" batteries



THE FRONT VIEW OF THE UNIT

FIGURE 3: *This picture shows the general location of the transformer, the Raytheon tube, the choke coils and the variable resistance.*



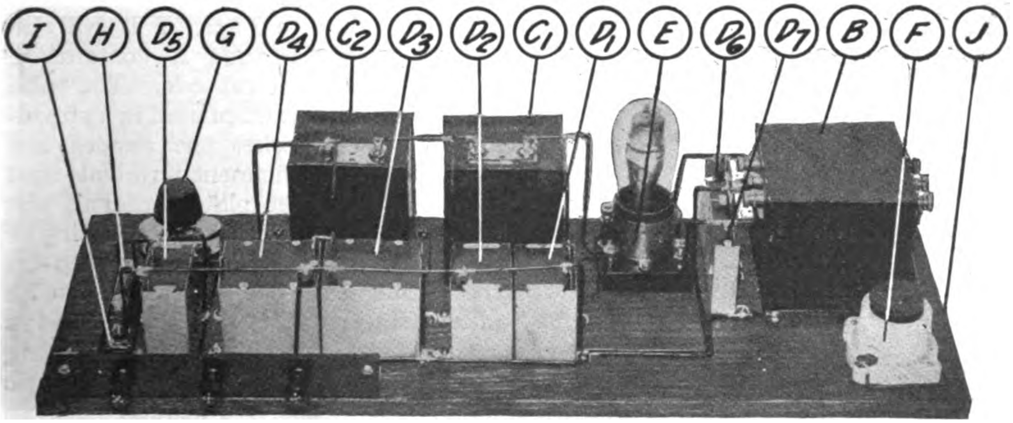
and thus places a heavy current drain on the plate-supply unit. This causes excessive filament emission from the rectifying tubes and reduces their life to a mere 250 to 300 hours. This is, of course, unsatisfactory.

There has been an insistent demand from the readers of POPULAR RADIO during the past year to have our Technical Staff tell them how to build a device of this sort, but we have withheld publication awaiting the development of this new device until it had reached the stage where the first cost would be the last cost and where the tube would be a permanent thing and where there would be no possibility of an alternating current hum in any receiver to which it might be attached.

This has finally been realized, and its application is due to the development of a remarkable new filamentless, double-wave rectifier tube—the Raytheon.

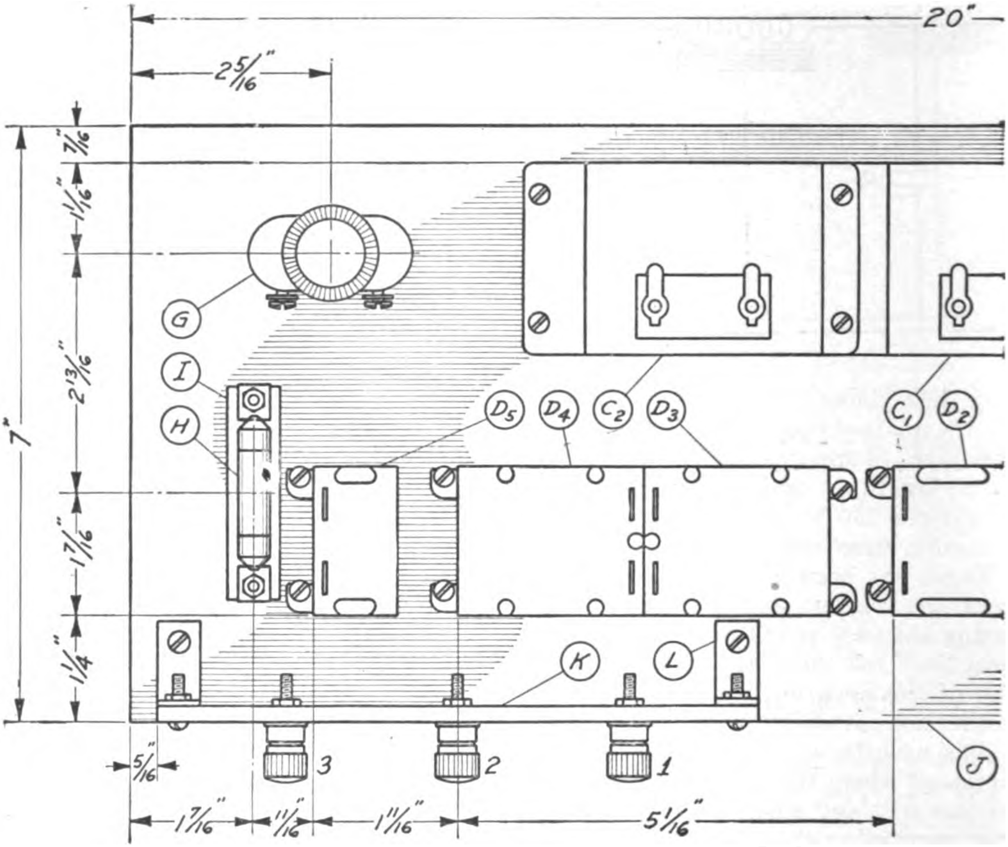
This tube is pictured in Figure 1.

The tube is the final development of the famous "S" tube which has been for years popular among the amateurs as rectifiers in their transmitting sets. Mr. C. G. Smith, the inventor, has finally produced a tube which is about the size of the ordinary receiving tube, but which takes the place of two large rectifier tubes heretofore used. It really is two tubes in one but contains no filaments and operates by means of ionization. The tube has been given a conservative rating of 150 volts at 60 milliamperes, taken from the output of the unit which will be described. Even on full load the full peak of the wave of the alternating current is rectified instead of being cut off as is the case of



THE REAR VIEW OF THE DEVICE

FIGURE 4: *This illustration shows the positions of the binding post strip, the fixed resistance, the condensers and the porcelain cleat receptacle for connection to the A.C. mains.*



THE WORKING DRAWING FOR CONSTRUCTION

Figure 5: *This drawing gives the correct dimensions and spacing for mounting all the component parts of the plate supply unit.*

the filament tube in which the load may cause the limited emission to cut off the current.

The advantages of this tube for use in such a device are the following:

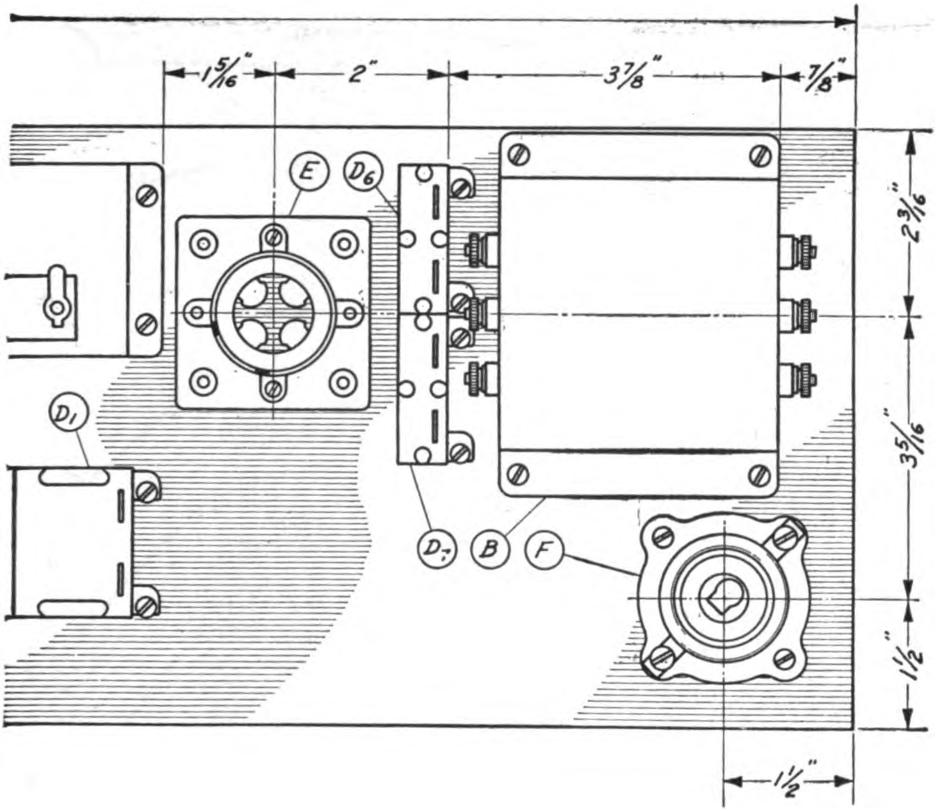
1. Full-wave rectification;
2. Filament-less operation;
3. Long life;*
4. High voltage output;
5. High current output;
6. Rugged construction;
7. Compactness;
8. Uniform results.

Since the development of the tube there has been a lapse of almost a year. During this time the design and functioning of numerous circuits have been under careful test and consideration. The final design, which has proven to be the most satisfactory, is the one which will now be described.

By referring to Figure 2 it will be noticed that the tube A contains 2 anodes and a single cathode. The tube is so arranged that when used in a standard UV-201-a socket the anodes are connected to the filament terminals and the cathode to the plate terminal, the grid contact being left open. The input to this tube is supplied from a step-up transformer that operates on 110 volts (alternating current) and that employs a split-secondary winding for applying half potential on each side of the tube through its prospective anodes. Stable operation of the rectifier is facilitated by means of two "buffer" condensers of low capacity which are designated on the

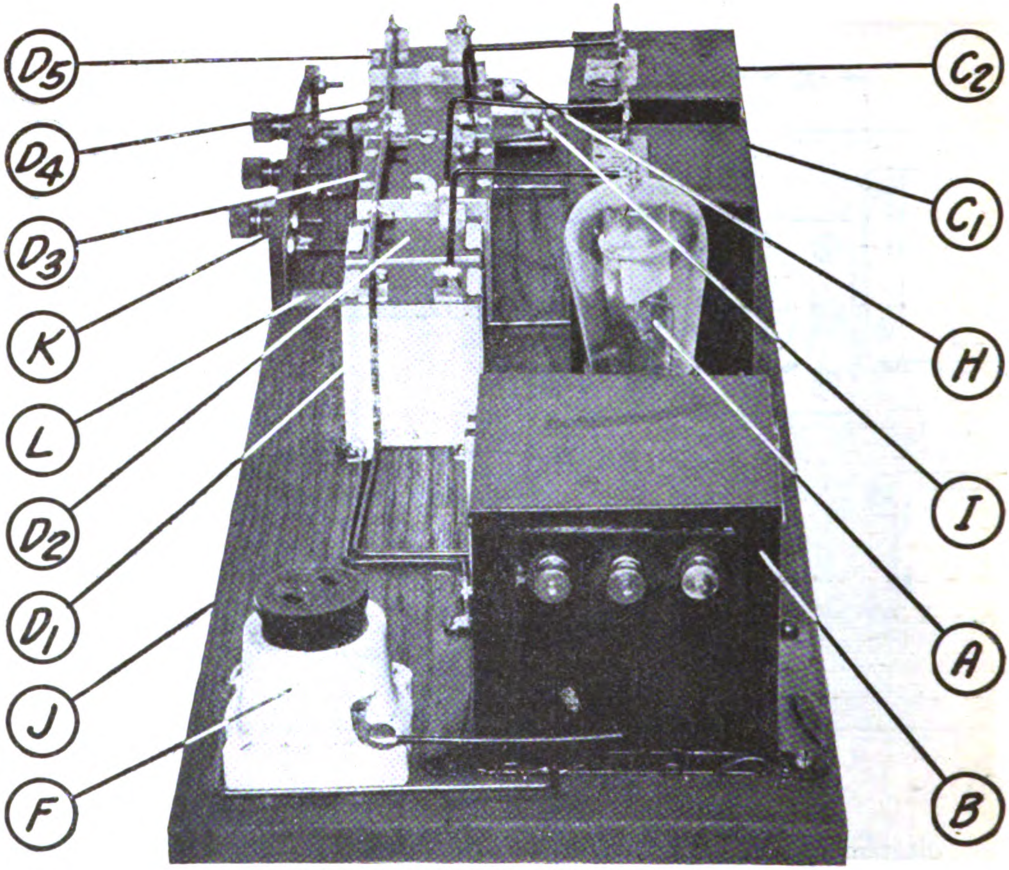
---

* These tubes have been tested upwards of 10,000 hours at full load without any sign of deterioration.



circuit diagram (Figure 2) as D6 and D7.

The rectified full-wave current is then applied across the terminals of the condenser D1 which voltage is then passed on through a large choke coil C1 and applied across the terminals of a second filter condenser, D2. The condensers act as voltage reservoirs and, as the choke resists variations in current, the voltage applied to D2 is very constant. The voltage across this condenser is then supplied through a second filter choke C2 and is stored up in the two larger condensers D3 and D4, which are connected in parallel and which act as the main reservoirs for the direct-current energy to be supplied to the tubes. The full voltage from the filter is then applied across terminals 1 and 3 which may be connected directly to the plate terminals of the amplifier tubes. Terminal 3 is about 90 to 105 volts positive and terminal 1 is negative. For reducing the voltage for use on the detector a suitable high-resistance G is inserted in series with the high potential line and another fixed resistance H is used directly across the plate circuit of the detector tube which may be connected between terminals 1 and 2, where 2 would be positive. These two resistances act as a potentiometer. A bypass condenser, D5 of 1 microfarad is placed across these two terminals to allow audio and radio-frequency currents to pass in the plate circuit of the detector without diminution. The resistance of the fixed unit H is rather low so that the plate-current variation of the detector tube is only a small part of the current flowing through H. This eliminates any trouble from a change in the dynamic operation of the detector tube through varying currents flowing through the variable resistance G, which otherwise might vary the voltage drop across G over wide limits that would be dangerous to quality reproduction. The unit is absolutely stable in operation, is



HOW THE UNIT LOOKS FROM THE LEFT

FIGURE 6: *In this picture of the input end of the unit the porcelain receptacle will be seen connected directly to the two left-hand input terminals of the transformer.*

permanent and will give perfect satisfaction to prospective builders who follow the details of construction that are given here.

Parts Used In Building the Unit

In all the diagrams in this article each part bears a designating letter; in this way, the prospective builder of a set may easily determine how to mount the instruments in the correct places and connect them properly in the electric circuit.

The same designating letters are used in the text and in the list of parts at the beginning of the article.

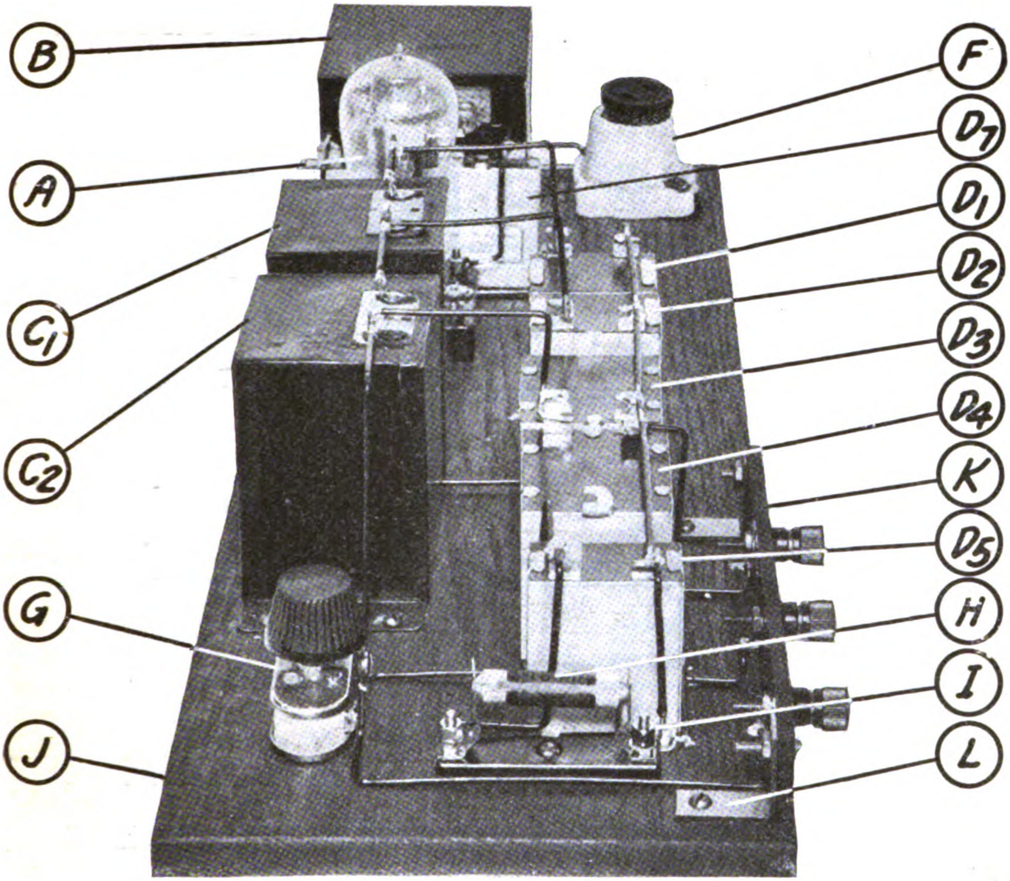
The list of parts there given incudes the exact instruments used in the unit from which these specifications were made up The experienced amateur, however, will be able to pick out other reliable makes of instruments which may be used with equally good results. But we recommend that the novice follow the list, as the diagrams in this article will tell him exactly where to bore the holes and exactly where to place the connections in wiring up.

If instruments other than the ones listed are used, the only change that will be necessary will be the use of different spacings for the holes that are to be drilled in the panel for mounting the instruments.

How to Construct the Unit

After procuring all the instruments and materials for building the unit, the experimenter should prepare the baseboard J. This should be made of one-half inch oak and cut to the size of seven inches by twenty inches as shown in Figure 5. When this has been done the baseboard should be dried out thoroughly by placing in an oven or in a warm place for a few hours and fastened securely under heavy weights to prevent warping Then it may be given a coat of shellac. When it has finally dried, the instruments should be mounted upon it.

First of all, mount the lighting socket F in its correct position by means of two wood screws as shown in Figures 4, 5, 6, 7 and 8. After this has been done fasten the transformer B in its proper position by means of four screws. Be sure that the output terminals are facing to-



HOW THE UNIT LOOKS FROM THE RIGHT

Figure 7: *This diagram shows the output end of the device with the binding post strip and the two resistances for obtaining a variable detector voltage.*

wards the left as in the plan view, Figure 5.

Then mount the two condensers D6 and D7 in their respective positions by means of four wood screws as shown in Figures 3, 4 and 5.

The two chokes C1 and C2 may next be placed in their respective positions as shown in the three same Figures.

Notice that the two middle mounting-flaps of the chokes C1 and C2 are placed one over the other so that only two screws are used between the two chokes for mounting instead of four, making a total of six screws for mounting the two chokes. (See Figure 5.)

Now, fasten the Bradleyohm G in its position by screws inserted through the holes underneath the knob which extends right through the instrument.

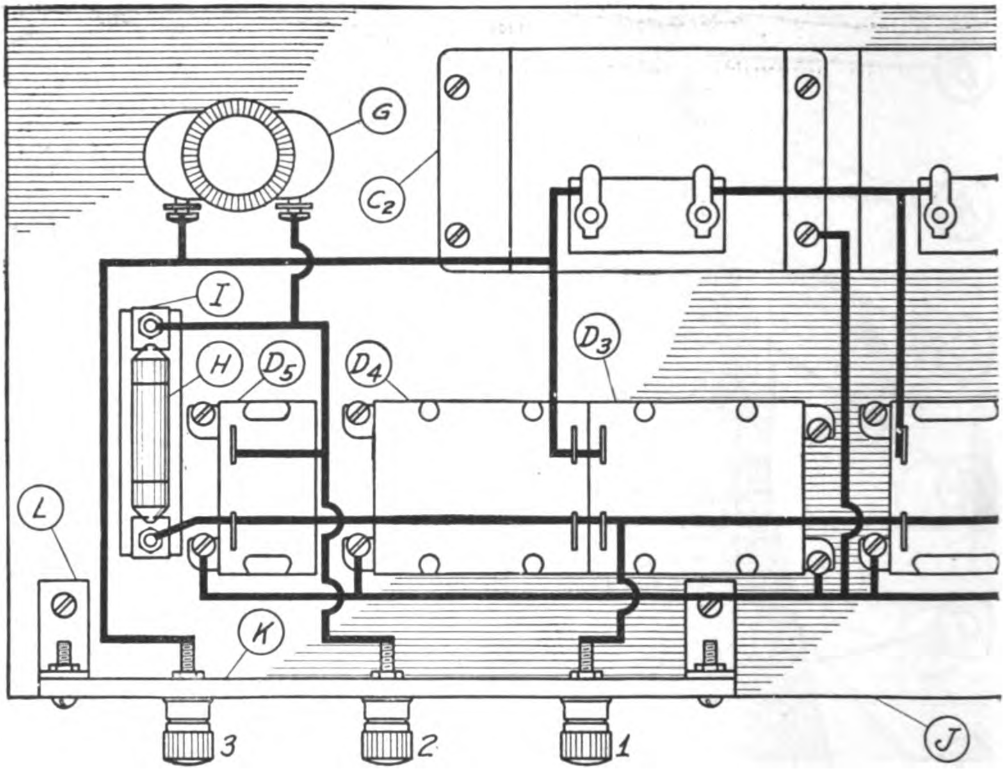
The next job will be to mount the two condensers D1 and D2 into position as shown in Figure 5. They may be mounted with two screws to each instrument.

Next, do likewise with the two condensers, D3 and D4. The flaps for mounting these condensers may be bent into the correct position as shown. When this is done finish mounting the condensers by placing D5 in its position and making fast by two more wood screws. Then place the resistance mounting I in place and attach to the sub-base with a screw in the same manner. Insert the fixed resistance H in its terminals.

Next, on the construction program will be the preparation of the binding-post strip K. This should be cut from hard rubber and drilled as shown in Figure 9. When it has been drilled, cut and bend the two brackets L as shown in Figure 9 and drill them for the screw holes that fasten to the strip and also to the sub-base. After they have been connected to the strip by means of two machine bolts and nuts the whole assembly may be tightened to the sub-base as shown in Figures 4, 5, 6 and 7 with two sturdy wood screws. The binding posts 1, 2 and 3 may then be attached and firmly tightened.

The last job will be to mount the socket E in its correct position as shown in Figure 5 with the socket slot pointing towards the left as denoted by the small black portion of the rim in the drawing. This is extremely important.

When this work is completed the unit is



THE PICTURE WIRING DIAGRAM FOR CONNECTING UP THE INSTRUMENTS

FIGURE 8: *All the instruments have been drawn in their approximate positions. The heavy black lines show the exact way to run the wires for connecting up the instruments.*

ready to be wired up and connected in the circuit.

How to Wire the Unit

The mechanical and electrical design of this device have been worked out with extreme care through many months of experiment and test. The whole unit is self-shielding and it is due to this as well as the electrical design of the filter circuit that there is no hum produced in the receiving set to which it is attached.

It is recommended that all wiring be done with an insulated, solid, round bus-wire.*

In wiring up refer constantly to the picture wiring diagram in Figure 8. Notice that in this arrangement of parts the alternating current as applied to the socket F is isolated from the output as obtained from terminals 1, 2 and 3 on the connection block K. The alternating-current transformer B is also fully shielded from the output. Notice that the cases of the transformers and the chokes and all the condensers are connected together on the negative side of the direct-current voltage which is on the center tap of the transformer and the binding post No. 1. *This provides full electrostatic shielding throughout.*

Start wiring by making the two connections from the socket F to the two low-voltage terminals of the transformer B. These are the two binding posts that should ordinarily be used with the ordinary set that requires about 90 volts or so. Where 125 to 135 volts is necessary, the wire that goes to the center terminal may be disconnected and attached to the far terminal (looking at the baseboard as shown in Figure 8); this results in a larger voltage ratio in the transformer with a correspondingly higher plate voltage applied to the set.

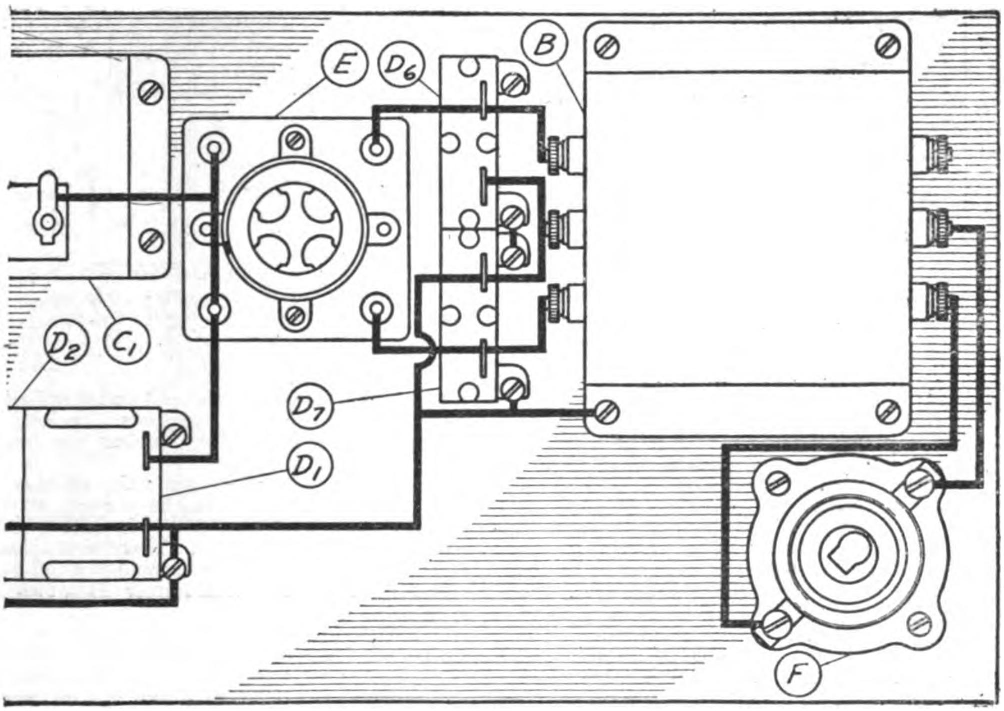
Next, run two wires from the outside secondary terminals of the transformer B to the outside terminals of the condensers D6 and D7 and extend these two wires over to the two right-hand terminals of the socket E.*

Next, join the two adjacent (inside) terminals of the condensers D6 and D7 by a wire that also goes to the middle terminal of the secondary of the transformer B. Extend this same wire to

---

* The type of bus wire used in all of the experimental set-ups and in the model which is being described was "Celatsite."

* Right-hand and left-hand and front and back as applied to wiring refer to the diagram in Figure 8. Front being the closest to the observer and back being the side of the instruments turned away from the observer.



the screws that fasten to the metal cases of the transformer B and both of the condensers D6 and D7. Also run this wire over to the cases of the condensers D1, D2, D3, D4 and D5. An extension of this wire should run to the front terminals of D1, D2, D3, D4 and D5 and also to the binding post No. 1 and the front terminal of the resistance mounting I. (See Figure 8.) Another extension of this ground lead should go to the front middle screw that fastens the two chokes C1 and C2 to the baseboard.

In making connection to the cases it will be necessary to file the metal lugs bright and shiny and then fasten the mounting screws down tightly and make soldered connections to them.

The next job will be to connect the two left-hand terminals of the socket E together by a wire and run one extension to the back terminal of condenser D1 and another extension to the right-hand terminal of choke C1. Then join the left-hand terminal of choke C1 to the right-hand terminal of choke C2 by a wire and run an extension from here to the back terminal of condenser D2. The left-hand terminal of choke C2 may then be attached by a wire to the two back terminals of condensers D3 and D4 and an extension run from this wire over to the left-hand terminal of the variable resistance G and also to the high-voltage binding post No. 3.

Next, run a wire from the back terminal of the fixed resistance mounting I over to the right-hand terminal of the variable resistance G and then run an extension from this point to the back terminal of the condenser D5, running a wire from there on to the binding post No. 2. This completes the wiring of the unit. Be sure that you have done it exactly as shown in Figure 8.

Check over your connections a number of times to be sure that you have made no mistakes. If you make every connection exactly as shown you will have no trouble in getting the unit to work properly. In doing your wiring job remember that care and neatness will enable you to do an efficient job. Don't hurry, but take it easy.

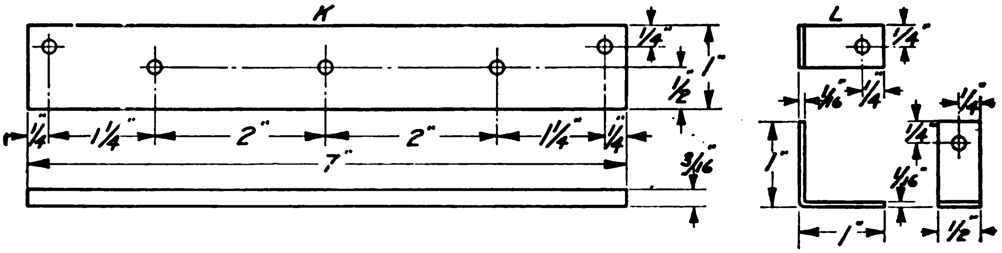
All of the instruments are marked with designating letters so that you should not make any mistakes.

How to Install the Unit

After the wiring has been completed the unit is ready to be installed and placed in operation so that it may furnish the direct current necessary for operation of the receiver that it is to be used in conjunction with. Place the unit in the radio table or cabinet where you have previously kept the "B" batteries in a position as shown in the photograph on page 406 with the transformer, the chokes and the adjustable Bradleyohm pointing toward you. Be sure that it is at least one foot distant from the receiver.

Next obtain a double-conductor cord with an ordinary light socket plug and jack attached to each end.

It is advisable to obtain about 15 feet of standard lamp cord and two lamp socket plugs for this purpose. Attach one of the plugs to each end. Then screw the detachable part of one plug into the Benjamin socket F on the plate-supply unit, and screw the detachable part of the other end of the cord into an ordinary lamp socket. When both ends of the cord are plugged in a connection will be made direct from the lighting line to the unit which will follow standard electrical practice and insure you against any possibility of fire or short-circuit.



DETAILS OF THE CONNECTION BLOCK AND SMALL BRASS BRACKETS

FIGURE 9: *This drawing gives the necessary data for making the insulating strip on which the binding posts are mounted. It also gives the dimensions for making the brackets that are used to fasten the strips to the base.*

Of course, the lighting socket fixture where you are taking off the juice should be turned off.

Next connect binding post No. 1 on the unit to the terminal of your radio receiving set that is marked "B" battery *minus* (—).

Then connect binding post No. 2 on the unit to your detector "B" battery plus (+) binding post on the receiver. Next connect binding post 3 on the unit to the amplifier "B" battery plus (+) binding post on the receiver. The unit is now ready to furnish a pure direct current (wholly unmodulated or without hum) to your receiver.*

Now turn on the rheostat and light your tubes to their correct brilliancy as you have in preceding times. Then turn on the switch at the light socket and your Raytheon plate-supply unit will start to function.

Next adjust the small knob on the variable resistor G until you get the correct plate voltage for the detector tube. It is best to set this at a rather high setting (turned out three-fourths of the way) and then tune in a station, after which the maximum signal strength and quality can be adjusted for with G. There are no further adjustments to be made on the unit and it will give you steady satisfaction for years. In fact, it should last you permanently unless you break the glass bulb of the tube.

To turn off the Raytheon unit, all that is necessary is to switch off the current at the socket as you would ordinarily do with a floor lamp or an electrical toaster. There is no upkeep beyond the expense of the extremely small current drawn by the transformer B which is negligible.

If all the instructions that are given in this article are followed minutely, even a beginner can build this unit and obtain very fine and enjoyable results both on local and distant reception.

---

* Be sure that the filament circuit of your receiver is grounded somewhere in the hook-up.

* The following manufacturers have been supplied with the design and also have placed on the market their own transformers and choke coils for use with the Raytheon plate-supply unit. All of these instruments have been built into the same type of unit in POPULAR RADIO LABORATORY as that described here, and they have all been approved for use in this circuit. This means that the experimenter may choose any of these makes according to his preference:

General Radio Co.; transformer type No. 365 and chokes type No. 366;
Jefferson Electric Co.; transformer type No. 355 and chokes type No. 356;
Dongan Electric Co.; transformer type No. 509 and chokes type No. 514.

Cockaday's Newest—and Best—Receiver

ONE of the centers of attraction at recent national radio shows was the newly developed Cockaday receiver. Judging from the interest shown in a model of this new development (which incorporates the principle of the Four-circuit Tuner with unified control and incorporating radio-frequency amplification as well as distortionless resistance-coupled amplification), it will be the most popular home-made receiver of the year 1926.

In this receiver, the name and description of which will be published in the December issue of POPULAR RADIO, the designer, while retaining all of the fine characteristics of the old Four-circuit Tuner, has made use of some of the newest and most important developments that have been made during the last year for obtaining *better sensitivity, more selectivity* and *purer reproduction.* The receiver will operate on any antenna between 10 feet and 200 feet in length—and may be built by the experimenter at a cost for parts not in excess of $60.00.

From a photograph made for POPULAR RADIO

HOW TO SCALE OFF THE ANSWER TO YOUR PROBLEM

With the position of the known specifications found on the chart on the opposite page, it is a simple matter to find the unknown specifications with no other help than that of a ruler and a good eye.

A MEASUREMENT CHART

FOR ESTIMATING THE INDUCTANCE OF A SINGLE-LAYER COIL

ARTICLE NO. 12

This article gives the amateur a quick method for determining the mechanical and electrical specifications of coils that are required for a certain band of wavelengths with specified sizes of condensers—thereby eliminating much loss of time in experimenting by the "cut-and-try" method.

By RAOUL J. HOFFMAN, A.M.E.

IN designing a radio circuit to cover a certain band of wavelengths using a condenser with a maximum and minimum capacity, the amount of inductance may be readily ascertained and thus the tapping of the coil may be eliminated.

In the following simplification of the well-known formula of Nagoaka,

$$L = \pi^2 d^2 n^2 l K \quad \ldots\ldots\ldots\ldots 1)$$

L denotes the inductance in microhenrys, d the diameter, n the number of turns to the inch, l the length of the coil and K the correction factor depending on the relation of l/d shown by the line A on the accompanying chart.

To simplify the formula we have replaced the curve *A* by the straight line *B*, which after evaluation will follow the equation.

$$K = .69\sqrt{l/d} \quad \ldots\ldots\ldots\ldots 2)$$

and by transposing equation No. 2 into No. 1 and by substituting for the metric units, the British units in inches we will have, the inductance

$$L = .0033\sqrt{l^3 n} \ldots\ldots\ldots\ldots 3)$$

wherein l denotes the total length of the wire used and n the number of turns to the inch.

Looking at the chart we see that the

How to Make Resistance Measurements

The next article of this series will explain how to make resistance measurements to determine the proper rheostat to employ in your receiving set for the multiple control of tubes. The value of the multiple control idea lies in the fact that it reduces the number of variable contacts in a filament circuit. A measuring chart will accompany this article. Besides, there will be a graph that will give tube data that any fan should be glad to get.

---

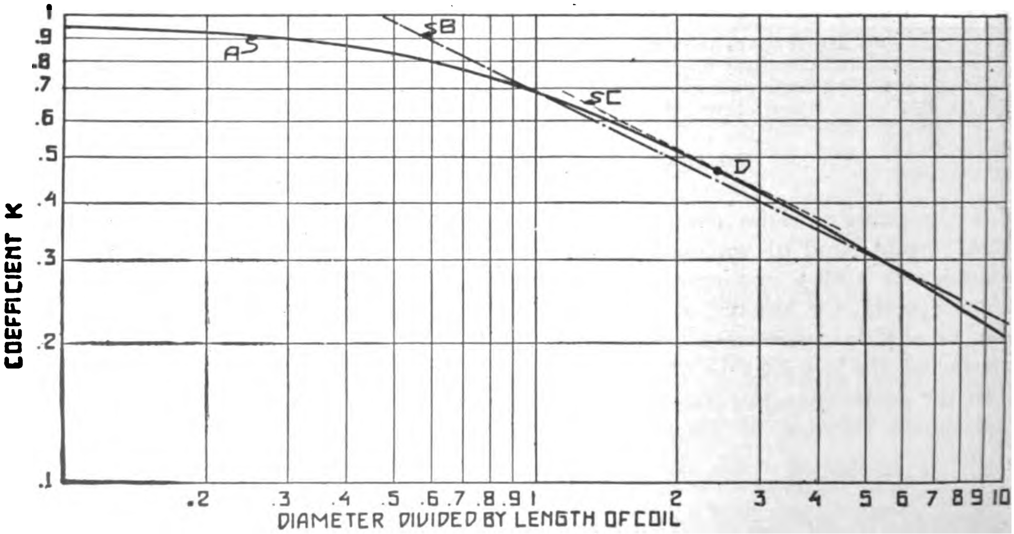
line *B* is within 3 percent of the line *A*, when the diameter of the coil is not larger than ten times the length and not less than seven-tenths of the length, which is within the limits of practical design.

Drawing a line *C* parallel with line *B*, we will have a point *D* on line *A* which denotes the maximum possible inductance for the same length of wire, which will be reached when the diameter is two and a half times the length of the coil.

The alignment chart shown will be a substitute for equation No. 3, when you connect the number of turns on scale No. 1 with the total length of the wire on scale No. 2 and read the inductance at the intersection on scale No. 3 in microhenrys.

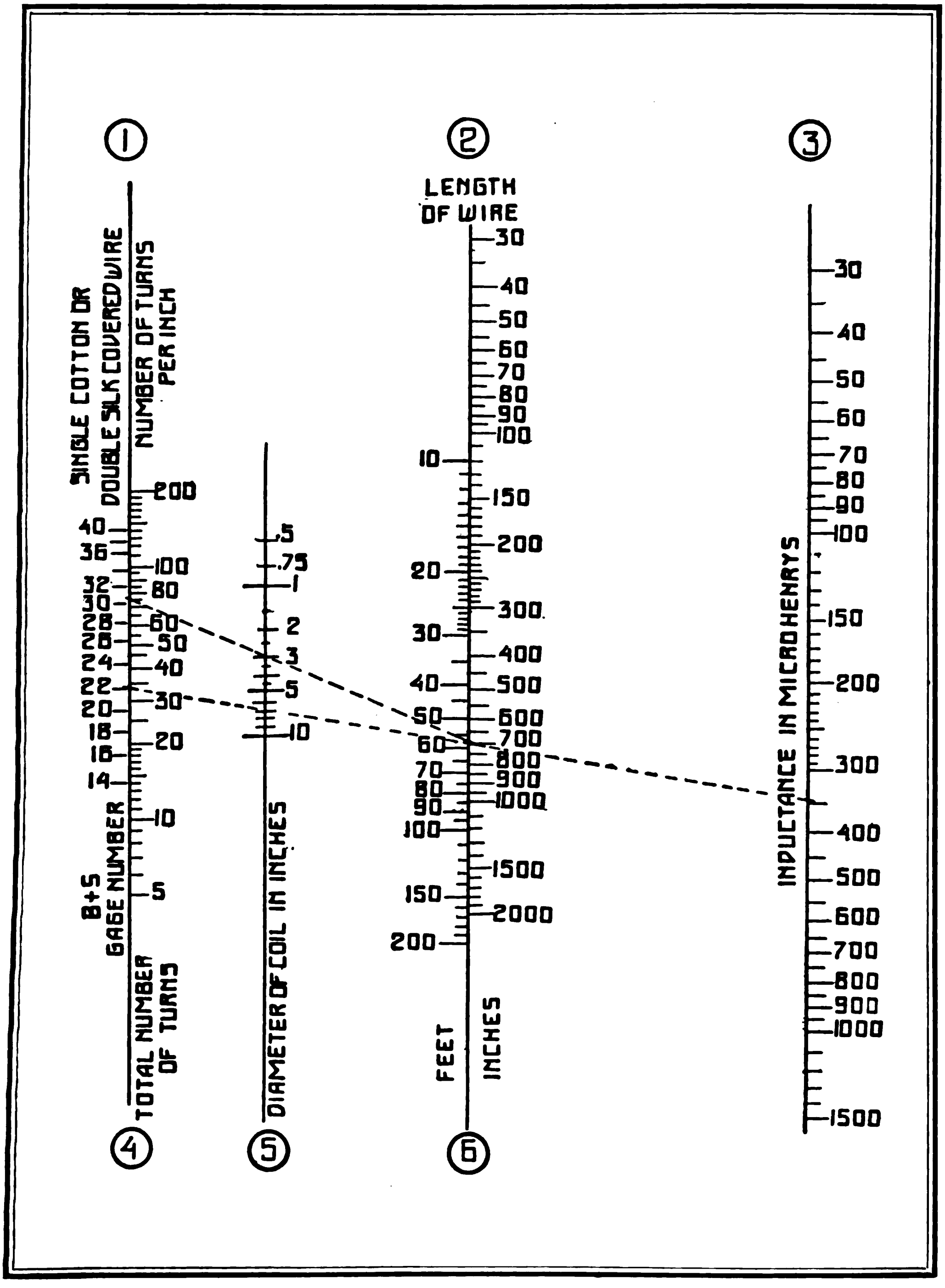
To find the total length of wire on a coil, connect the total number of turns on scale No. 4 with the diameter of the coil on scale No. 5 and read, at the intersecting point on scale No. 6, the total length in inches or feet.

Example: To find the inductance of a coil 3 inches in diameter with 75 turns of No. 22 DSC wire closely wound, connect 75 on scale No. 4 with 3 on scale No. 5, and the length of 700 inches on scale No. 6; then connect No. 22 on scale No. 1 with 700 on scale No. 2 and you will find that the line intersects scale No. 3 at 345 microhenrys which is the inductance of the coil.



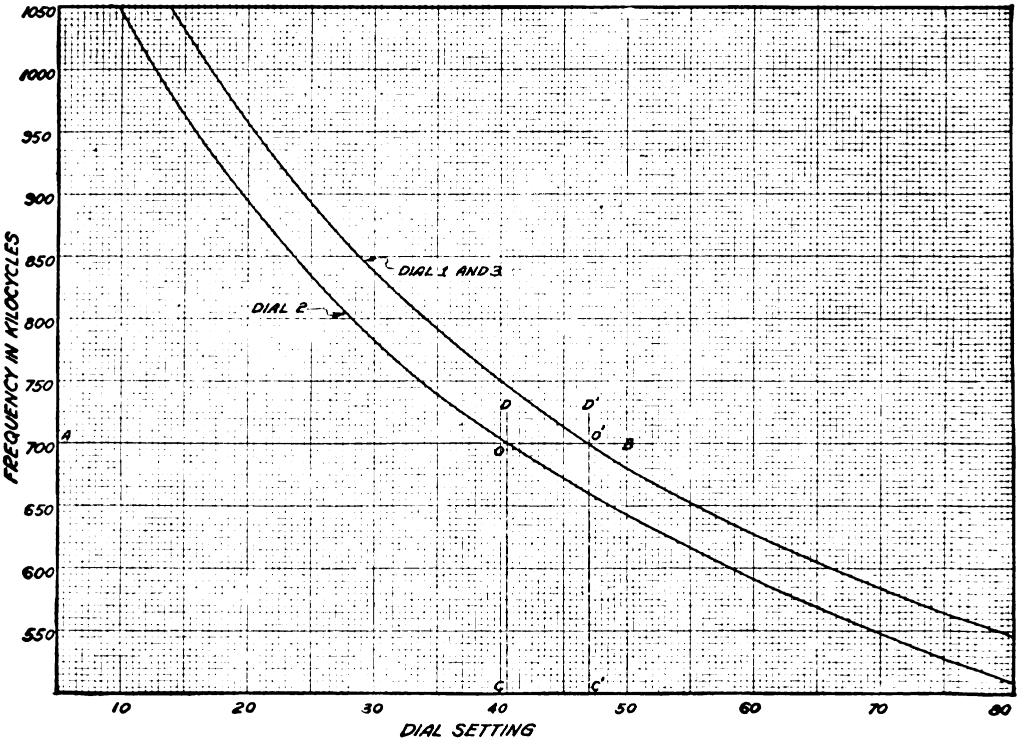
HOW THE MATHEMATICAL BASIS FOR THE MEASUREMENT CHART IS DETERMINED

This graph shows how the formula of Nagoaka was plotted and modified to find the lines B and C which are sufficiently accurate for the practical use of the measuring chart on the opposite page.



THIS IS THE CHART THAT CALCULATES FOR YOU

The text of this article tells you exactly how to determine the inductance of single-layer coils. This chart can be used for estimating inductances of practically all coils that are now in general use in radio receiving sets. It can only be used accurately, however, for solenoid types of inductance coils.



A SPECIMEN FREQUENCY TUNING CHART

FIGURE 1: *This chart shows exactly how to set the dials of a standard neutrodyne receiver for any specific frequency within the broadcast range.*

NEW METHODS OF Calibrating Your Receiver

This article describes a method for preparing charts for your receiver that will tell you exactly where to set the dials for any station, the wavelength or frequency of which you already know. One of these charts will give you a permanent record of the dial settings for all the stations that are listed in the call book.

By MORRIS S. STROCK

NO one can deny that a good deal of the fascination of radio comes from receiving the programs of distant stations.

The fad of spotting numerous stations merely for the purpose of hearing the announcer is not to be commended; nevertheless, it is true that, given two equally enjoyable programs, nearly everyone prefers to listen to the one that comes from the greater distance, although it may not be received as well.

A tabular record of stations heard is often used to assist in resetting the dials of the receiving set to a particular broadcasting station. This method requires the locating of each individual station. Sometimes the dial settings that correspond to the frequency or wavelength of a new station can be estimated from the table, but this is usually unsatisfactory in the case of distant stations.

NOTE: This article has been approved for publication by the Bureau of Standards.

A second method of finding the dial settings that correspond to the frequencies of broadcasting stations, consists in locating a few stations that have a uniform separation over the broadcast frequency band and then in plotting curves from this data. The curves furnish a graphical method of obtaining the dial settings corresponding to a given frequency. Typical curves are shown in Figure 1. One curve is plotted for each frequency control dial on the receiving set. Curves plotted to wavelength instead of frequency have the form shown in Figure 2.

Although this method is pretty generally known, it is not widely used. This may be due to the fact that the plotting and reading of curves appears difficult to the non-technical man. It is also probable that the advantages of this method are not generally appreciated. These advantages are:

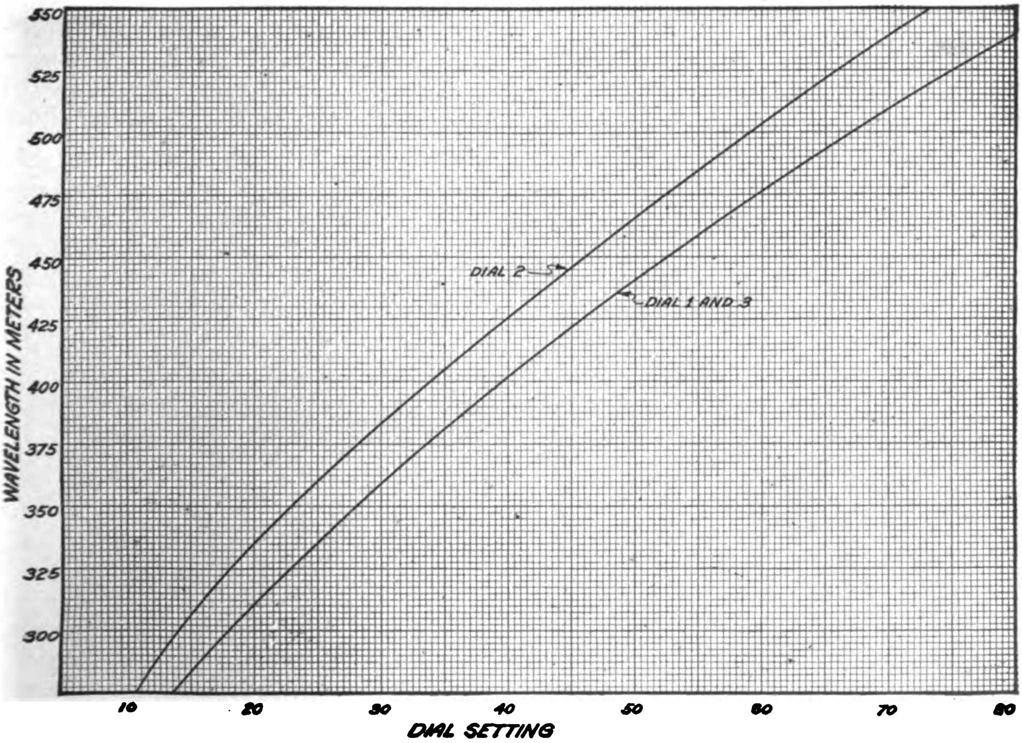
(1) The elimination of hunting for new stations;

(2) The maintaining of a permanent calibration for the receiving set.

In explanation of the first point it may be stated that when curves are employed with sets that have a high degree of selectivity, one may often locate a distant station which normally would not be heard.

The importance of the second point is evident when one considers the recent changes in frequency assignments to broadcasting stations and the difficulty of relocating these stations on the receiver dials. With the aid of curves, the dial settings that correspond to a new frequency assignment can be immediately determined.

It is the purpose of this article to describe the method of obtaining and



A CHART THAT INCORPORATES A TUNING RECORD IN WAVELENGTH

Figure 2: *This gives you at a glance the correct dial settings for any of the wavelengths that lie within the present broadcast waveband. The text of the article explains how to make these charts and how to use them.*

using accurate calibration curves. In this, the use of certain stations which maintain a constant frequency close to their assigned values is suggested. These stations, which are known as "Standard Frequency Stations," are listed each month in the Department of Commerce *Radio Service Bulletin.** The data given on page 422 (with the addition of a wavelength column) are taken from a recent issue of that publication.

These stations are measured regularly at the Bureau of Standards, and as shown in the table, have extremely small deviations. In all probability there are many other broadcasting stations that maintain frequencies close to the assigned values; the stations in this list are, however, of known reliability. If the broadcast listener is able to receive all of the Standard Frequency Stations they will enable him to obtain reliable curves which will assist in adding distant stations to the radio log.

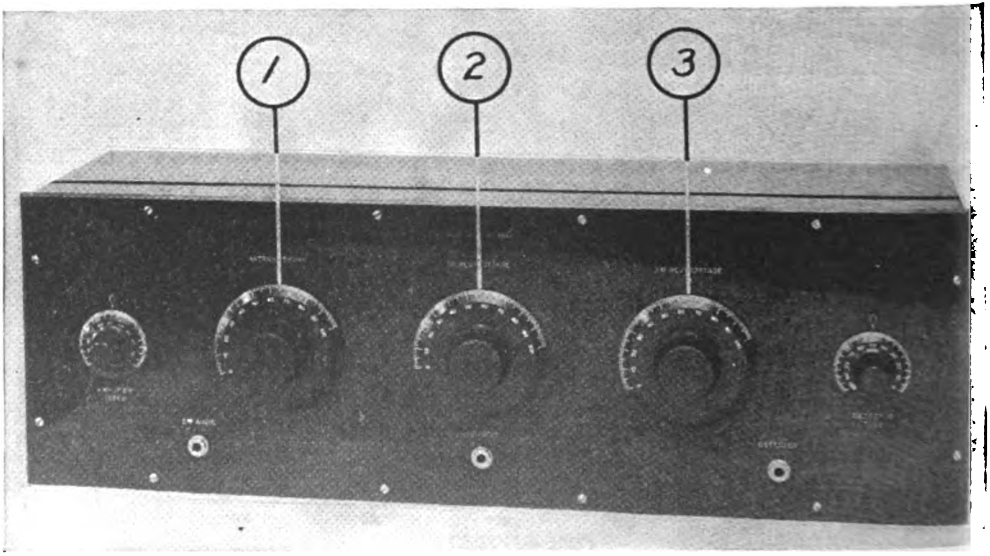
As many stations deviate somewhat from their assigned frequencies, they will not always be found on the receiver dials at the exact settings indicated by the curves. Since, however, the deviations may be in either direction, the calibration curves obtained from Standard Frequency Stations will follow what may be termed a mean path between the deviating stations and consequently, a minimum error will be introduced in obtaining the dial settings.

The importance of using Standard Frequency Stations for obtaining curves increases in direct ratio with the selectivity of the receiving set.

Sets that have a high degree of selectivity are generally also very sensitive, and in the eastern part of the country should permit reception of all Standard Frequency Stations. Sets of moderate sensitivity and selectivity may not be capable of picking up all of these stations. These sets will not permit of extremely close dial settings; their calibration curves will be slightly less accurate; consequently it is not so necessary to depend entirely upon the Standard Frequency Stations for obtaining these curves.

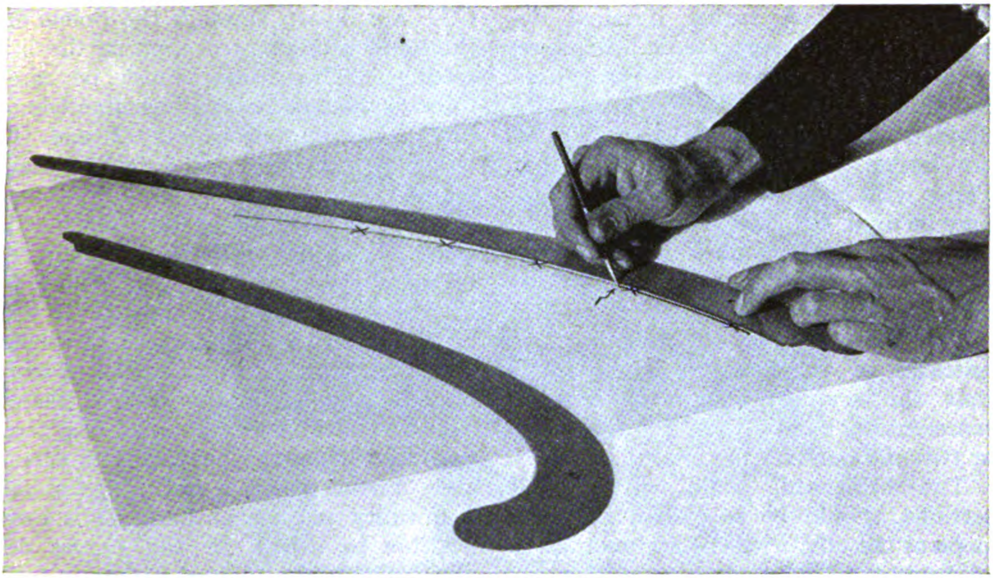
---

* Obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 25 cents a year.



A STANDARD NEUTRODYNE

FIGURE 3: *This is a receiver that was used in making up the chart shown in Figures 1 and 2. The dials marked 1, 2 and 3 correspond with the curves which are also marked with the same designating numbers so that the operator may know exactly at what settings they should be adjusted for various wavelengths or frequencies.*



INKING IN THE CURVE

Figure 4: *This photograph shows how the various points that have been plotted on cross-section paper are connected with a smooth curve line which is guided by a set of French curves.*

Owing to the fact that frequency allocations to broadcasting stations are determined by a uniform separation of ten kilocycles, the use of kilocycles in plotting and reading curves offers the advantage of simplicity; but as broadcasting stations are generally listed in meters, it will be necessary to make conversions. These conversions are easily made and the small amount of time required to do this will be found worth while. To change meters to kilocycles or to change kilocycles to meters, divide either quantity into 300,000. In the former conversion, the resulting number of kilocycles which is nearest an even multiple of ten should be chosen.

Figure 1 shows three curves obtained from the Standard Frequency Stations by the use of a neutrodyne set, a picture of which is shown in Figure 3.

In this set it so happens that curves for dials 1 and 3 are practically identical.

Figure 2 shows curves for the same receiving set that uses wavelengths instead of frequencies. As the curves furnish a permanent calibration, attention should be given to all features of the receiving installation which might cause a change in the dial settings for a particular frequency. In general it will be necessary to see that the receiving antenna and ground wire are permanently installed and even the question of approximately constant "B" battery voltage and filament currents should be given some attention unless it has been definitely ascertained that these factors will have no effect upon the calibration of the receiving set.

This is the method employed for obtaining and for using the curves in Figure 1, although using the dial settings for the neutrodyne set, is applicable to all types of receiving sets.

The dials of the receiving set were carefully adjusted to obtain a maximum signal from each Standard Frequency Station, giving data as shown on page 422

These observations represent the average of several trials. Care was taken to read the dials with the eye of the observer directly in front of the zero markings.

The plotting of curves from the data obtained from the receiving set requires care, as the dial settings for the various broadcasting stations are obtained from these curves. A rather detailed description of this process is, therefore, required. The cross-section paper used for this purpose should be accurately divided into small squares, preferably not larger than about one millimeter. Paper with larger subdivisions than this may be used, but this will require a sheet of rather inconvenient size in order to obtain an accurate frequency or wavelength scale.

The vertical scale, representing frequencies of wavelengths, is chosen so that the smallest square or division represents not more than five kilocycles or two and one-half meters.

The horizontal scale, giving dial settings, should be so chosen that the slope of the curve will be approximately 45 degrees.

The curve shown in Figure 1 was plotted on cross-section paper divided into one-millimeter squares. On the vertical axis, one millimeter represents five kilocycles, and one the horizontal axis, two millimeters represent one division on the receiver dials.

The following explanation shows the method of plotting points on the curve sheets:

The frequency or wavelength of the broadcasting station is located on the vertical axis and the corresponding dial settings are located on the horizontal axis. A light horizontal line, AB (Figure 1), is drawn through the frequency point and vertical lines CD and C'D' are drawn through the points on the horizontal axis representing the dial settings. These lines must be carefully located so as to determine accurrately intersecting points O and O'. Other points are located in the same manner.

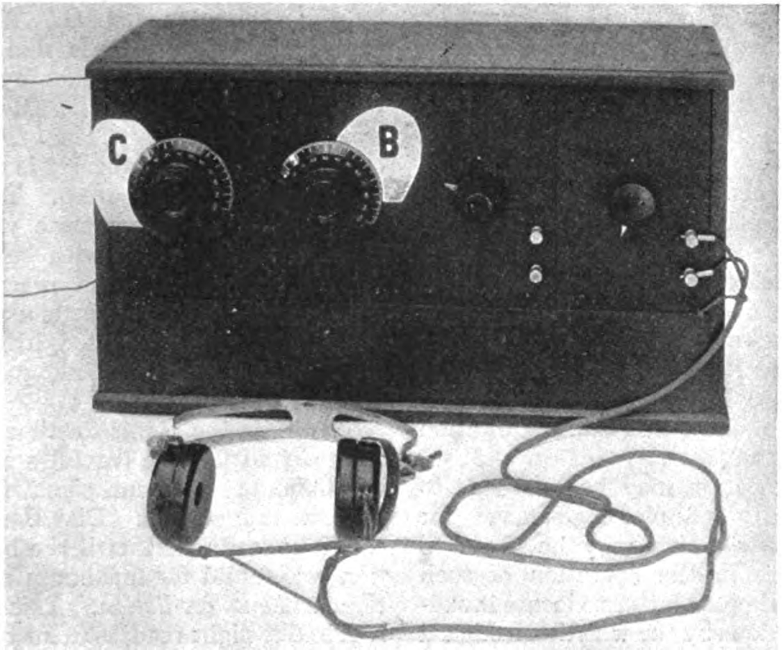
These points are to be joined with smooth even curves. For this purpose, celluloid curves of the type shown in Figure 4 are most satisfactory. In lieu of this, one may use a piece of rubber insulated copper wire of sufficient stiffness to remain in any desired shape. The wire is first straightened and then carefully bent to the required curvature, as the eye is a fair judge of the uniformity of curved lines, it is even possible to sketch in the curves determined by the plotted points in freehand fashion. The inaccuracies involved by this process will be greatly reduced when the points are plotted to a larger scale than previously mentioned. The adoption of any of these methods does not warrant a lesser degree of care and accuracy in locating the required points.

The explanation given below assumes that the curves are drawn with the aid of curves forms and inked in with a draftsman's ruling pen. It will also be of assistance in obtaining reliable curves when some other method is employed.

The curve forms are so choosen that the edges approximate the curves determined by the points. In starting the

Station	*Location*	*Assigned frequency (kilocycles)*	*Assigned wave-length (meters)*	*Period covered by measurements (months)*	*Number of times measured*	*Average percentage deviations from assigned frequencies noted in measurements*
WEAF	New York, N. Y.	610	491.5	3	**35**	.0
WCAP	Washington, D. C.	640	468.5	18	**81**	.1
WRC	Washington, D. C.	640	468.5	15	**61**	.1
WSB	Atlanta, Ga.	700	428.3	18	**70**	.1
WGY	Schenectady, N. Y.	790	379.5	21	**115**	.1
WBZ	Springfield, Mass.	[1]900	333.1	11	**29**	.1
KDKA	East Pittsburgh, Pa.	[2]970	309.1	18	**143**	.1

THIS TABLE GIVES A LIST OF STANDARD FREQUENCY BROADCASTING STATIONS.



A REGENERATIVE RECEIVER

FIGURE 5: *The chart shown in Figure 6 incorporates the dial settings for the wavelength control C and the regeneration control B. This is a more difficult type of receiver to chart, although it is readily accomplished if the details of the text are followed closely.*

curve, the celluloid form is fitted to at least three points. The curve is then drawn only part way to the third point, and the celluloid form is readjusted so that it exactly coincides with a portion of the curve previously drawn and so that it includes at least two two additional points.

This method is illustrated in Figure 4, in which the heavy line represents the inked portion of the curve, the double line represents the curve as previously drawn in pencil, and the arrow represents the point where the inked line is stopped preparatory to shifting the celluloid form before it *begins* to diverge from the pencilled curve.

The curves may be accurately extended beyond the limiting points determined by the Standard Frequency Stations provided a uniform rate of curvature is adherred to.

The use of the completed curves to determine the dial settings on the receiving set corresponding to the frequencies of broadcasting stations is similar to the procedure used in plotting points for the curves. From a point on the vertical axis (Figure 1) representing a frequency of say, 650 kilocycles, a horizontal line is projected to the right until it intersects the curves. From these intersecting points vertical lines are projected downward, giving points of intersection with the horizontal axis, 49 and 55.5, which determine the dial settings for 650 kilocycles.

The data obtained in this manner should be recorded in a table giving the broadcasting station, the frequency, and the dial settings corresponding to that frequency.

When the dials of the receiving set are adjusted according to this data, it will in some cases be necessary to make only slight changes in the settings in order to obtain signals of maximum intensity. This condition will generally be caused by a slight deviation of the broadcasting station from its assigned frequency. In the event of a station being assigned a new frequency, the new dial settings can be immediately determined from the curves.

Although these instructions are based upon curves for the neutrodyne set, the ideas there given apply to various kinds of receiving sets. Circuits that employ regeneration will usually show an appreciable change in the setting of the tuning dial for a particular broadcasting station when the dial controlling regeneration is readjusted; hence it is desirable to consider certain refinements in obtaining and using calibration curves for such sets.

Some objection may be raised as to the necessity of plotting curves for receiving sets which may be made to generate, as in the operation of such sets it is a simple matter to locate broadcasting stations by the whistles produced with the carrier waves. As this method results in interference to other receiving sets it is objectionable on that score. It is also true that if one has a dial setting obtained from a curve, he is more apt to wait for that particular station, provided it is reasonably certain that the dial setting is correct. In using calibration curves for receiving sets of the regenerative type, distant stations may usually be located without the production of disturbing whistles. This result is secured in the method described below.

Figure 5 shows a regenerative set having an untuned primary circuit with fixed coupling to the secondary. The range of broadcast frequencies is covered by the condenser dial, C. The small knob directly below this dial is used to obtain a fine adjustment by friction with the edge of the dial. Dial B controls regeneration. The calibration curve obtained from this set is shown in the upper part of Figure 6. The lower curve shows the approximate variations in settings of dial B with settings of dial C giving maximum regeneration. This second curve represents a mean between the points as plotted, it being impractical to obtain these points accurately.

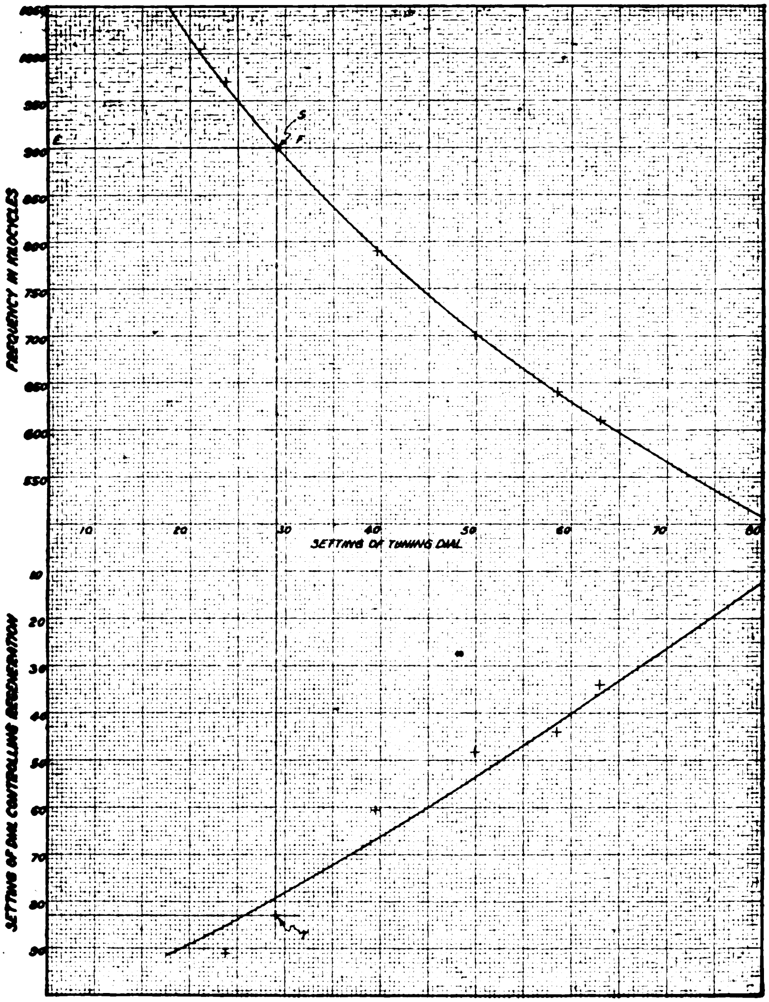
To obtain the points for these curves, dials B and C were carefully set to an approximate maximum signal from the broadcasting station. Dial B was then carefully readjusted until the best position was found for maximum regeneration *without oscillation*. This process required a slight readjustment of dial C. The settings of the two dials were then recorded together with the assigned frequency of the broadcasting station. Dial settings for other broadcasting stations were obtained in the same manner.

After the settings of dials C and B were determined for the Standard Frequency of other broadcasting stations, the points were plotted on cross-section paper in a manner similar to that described. The method of locating the points for the two additional curves was as follows:

The settings for dials C and B for a broadcasting station of 900 kilocycles were found to be 29 and 83 respectively. From the 900-kilocycle point on the

Station	*Frequency in kilocycles*	*Wavelength in meters*	*Dial 1*	*Dial 2*	*Dial 3*
WEAF	610	491.5	64.5	56.4	64
WRC WCAP	640	468.5	59.4	52	57.6
WSB	700	428.3	47.2	41	47.4
WGY	790	379.5	35	29.4	34.8
WBZ	900	333.1	24	19.3	24
KDKA	970	309.1	19.4	14.8	19.5

A SAMPLE TABLE THAT MUST BE PREPARED IN PREPARATION FOR THE CHARTS.



THE TUNING CHART FOR A REGENERATIVE RECEIVER

Figure 6: *These two curves give the dial settings for the dials B and C of the regenerative receiver shown in Figure 5. The upper curve gives the setting of the dial B in frequency and the lower curve gives the corresponding setting of the dial C.*

vertical axis (Figure 6) a horizontal line EF was drawn to the right and a vertical line was drawn up from a point on the horizontal axis corresponding to a dial setting of 29. This determined a point, S, for the upper curve. The vertical line was then extended downward below the horizontal axis. From a point on the lower vertical axis corresponding to a setting of 83 for dial B, a horizontal line was drawn to the right, giving an intersecting point, T.

When all the points were located in this manner they were connected with smooth curves as already described.

The data from these curves should be recorded in a table that gives the broadcasting station, its assigned frequency, and the required dial settings.

Assume that it is required to obtain the dial settings for a station with a frequency of 650 kilocycles. From this point on the vertical axis, a line is projected to the right until it intersects the upper curve. From this intersecting point a line is projected down until it intersects the lower curve. From this point a third line is projected to the left and the point of intersection with the vertical axis determines the approximate setting of the dial controlling regeneration.

In obtaining data for curves for a regenerative set which has a small (vernier) condenser connected across the terminals of the tuning condenser, it will be necessary to maintain a definite setting of this small condenser. This setting should preferably give one-half the capacity of this condenser. In the subsequent use of the set, the small condenser is turned to the same position, the proper settings of the other dials are obtained from the curves, and the small tuning condenser is used for the final tuning adjustment.

The data obtained from the curves of the type shown in Figure 6 will give airly reliable dial settings that correspond to the frequencies of various broadcasting stations. As the lower curve is less accurate than the upper curve, the method of setting the dials of the receiving set will require most careful attention to the setting of the dial that controls the tuning; that is, dial C in the set shown in Figure 5. Having set the dials at the predetermined points, the detector filament rheostat is carefully adjusted until maximum regeneration, without oscillation, is obtained. A slight readjustment of the dial controlling regeneration may then be made.

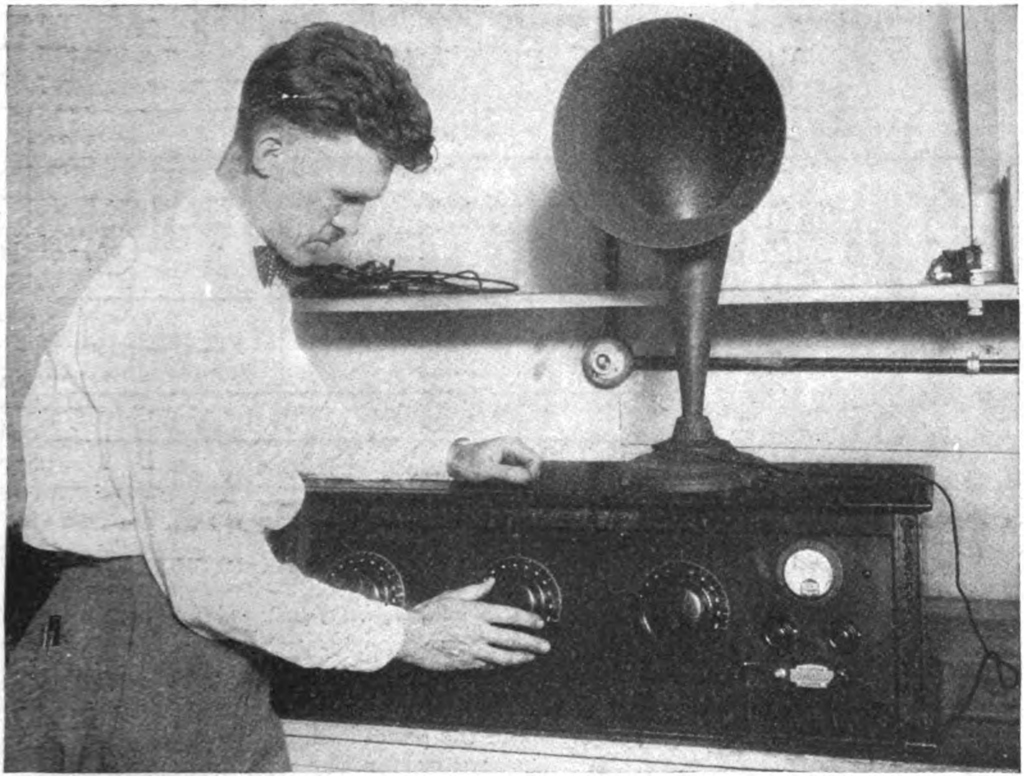
A careful following out of these instructions for obtaining and using calibration curves for receiving sets should result in reception from an increased number of stations and, in the case of regenerative sets, there will be an almost total elimination of radiating interference.

Kadel & Herbert

IS THIS THE "LARGEST RADIO RECEIVING SET IN THE WORLD?"

Anyway, it is one of the largest. It was built by Robert J. Sieglack of Sheepshead Bay, N. Y., at a cost for parts alone said to be over $3,000. It is a special superheterodyne circuit and employs twenty-three tubes.

¶ The helpful information incorporated in the articles of this series is obtained by independent and unbiased experiments conducted by the staff of the POPULAR RADIO LABORATORY.



HOW TO GET THE MOST OUT OF

YOUR READY-MADE RECEIVER

No. 9: THE GAROD NEUTRODYNE TYPE V RECEIVER

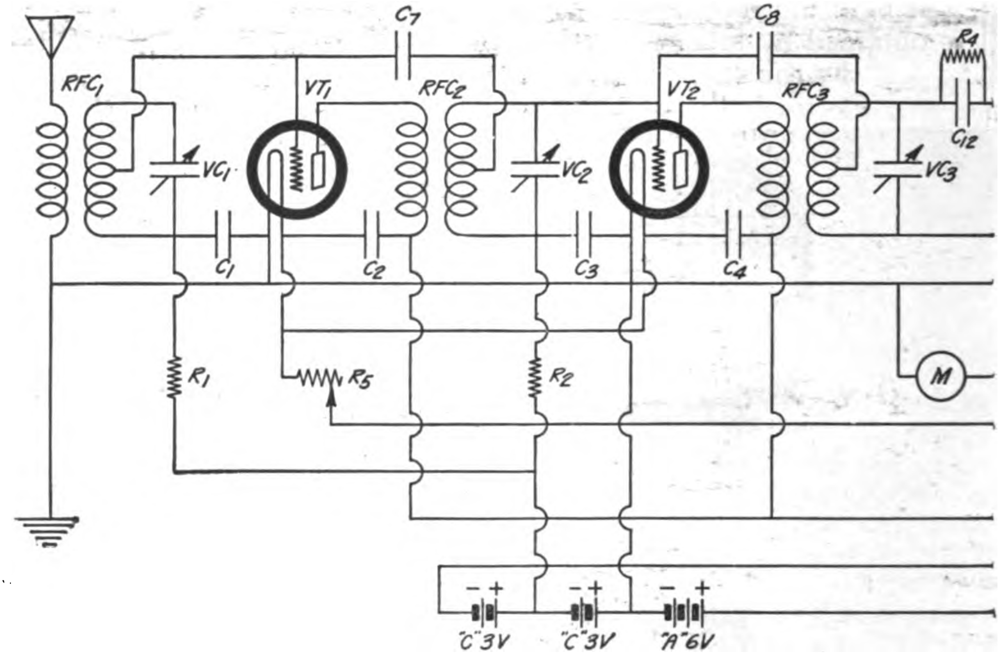
This series of articles explains the theory, operation, equipment and care of standard receiving sets

This series does not indorse the product of any manufacturer or make comparisons between receivers. The sets already described include: No. 1, the Eagle Neutrodyne; No. 2, the Radiola Superheterodyne; No. 3, the Melco Supreme Receiver; No. 4, the Crosley Trirdyn; No. 5, the De Forest Reflex; No. 6, the Atwater Kent; No. 7, the Grebe Synchrophase Receiver; No. 8, the Freed-Eisemann Receiver.

By S. GORDON TAYLOR

EXPLANATION OF SYMBOLS IN FIGURE 1—

RFC1—Antenna coupling coil;
RFC2 and RFC3—Radio-frequency coupler coils;
VC1, VC2 and VC3—Variable condensers;
VT1, VT2, VT4 and VT5—UV-201-a or C-301-a vacuum tubes;
VT3—UV-200 or C-300 vacuum tube;
AFT1 and AFT2—Audio-frequency amplifying transformers;
R1 and R2—Blocking resistances;
R3—Smoothing resistance;
R4—Grid-leak resistance;
R5 and R6—Filament rheostats;
R7 and R8—Automatic filament controls;



THE WIRING DIAGRAM OF THE GAROD NEUTRODYNE RECEIVER, TYPE V

Figure 1: *The designating symbols used are explained in the list of parts and in the text.*

C1 to C12—Fixed condensers;
M—Double range voltmeter;
M—Meter resistance coil;
S1—Battery switch;
S2—Voltmeter switch;
J—Phone jack.

THIS five-tube receiver is of the tuned-radio-frequency amplification type, making use of the neutrodyne method of preventing oscillation in the radio-frequency amplifier stages. A description of the theory of operation of this type of receiver has already been given in this series of articles.*

Construction of the Receiver

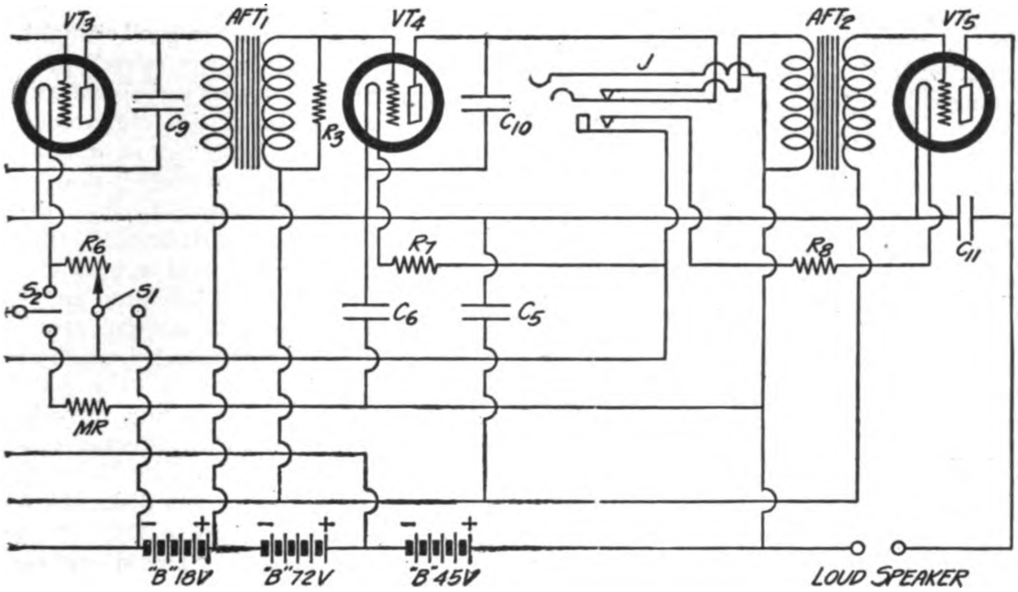
The receiver is of ample size to permit plenty of spacing between parts, thus preventing to a large extent undesirable interaction between the various circuits. The panel is of wood, finished to match the cabinet; the tuning controls are likewise finished in a shade to match the rest of the receiver. Ease of tuning is made possible by the use of large dials and the panel is sloping so that it is not necessary for the operator to crouch down before the receiver in order to tune it.

The parts of the tuning instruments which come in contact with the wood panel are at low potential. This is not important, however, inasmuch as well seasoned and finished wood is an excellent insulator, with little possibility of electrical leakage. The balance of the instruments are mounted on a wooden sub-base to which the panel is also attached. Thus the entire "works" may be readily removed from the cabinet if necessary, as shown in Figure 3.

The two radio-frequency-amplifier tube sockets are mounted directly on the sub-base but the detector and audio-frequency-amplifier sockets are placed on a rubber strip which in turn is mounted on two springs. Thus vibrations are absorbed by the cushioning

---

* Those who wish to familiarize themselves with the theory of operation are referred to the articles of this series which appeared in Popular Radio for December 1924 and August 1925.



springs and microphonic tube noises, sometimes encountered when a radio receiver is jarred, are eliminated. Vibrations do not cause trouble in the case of the radio-frequency-amplifier tubes; therefore a cushioned mounting is not necessary so far as they are concerned.

The cabinet itself is of mahogany and presents a pleasing appearance. Access to the receiver for inserting vacuum tubes and connecting battery leads is gained by removing a panel at the rear of the cabinet.

How the Receiver Works

The first two vacuum tubes, from the left (looking from the front of the receiver) are the radio-frequency-amplifier tubes. It is the function of these two tubes and the accompanying equipment to amplify the incoming signals in the exact form in which they are received. This is in the form of an alternating current of high frequency—much too high to lend itself to audible reproduction. Before reproduction is possible, the signals must pass through what is called a detector. In this receiver another vacuum tube is used as a detector and is placed near the panel on the right-hand side of the receiver. If headphones were connected in the output circuit of this detector tube the incoming signals would be distinctly heard, the headphones serving to transform the electrical energy, after it has been rectified by the detector tube, into sound energy.

Instead of connecting the headphones into the output circuit of this tube two more amplifier tubes are provided, the purpose of which is to amplify the rectified current from the detector thus making the use of a loudspeaker possible.† These two audio-frequency-amplifier tubes are those directly behind the detector (VT4 and VT5, Figure 3).

Tuning the receiver to the incoming signal is accomplished by means of three variable condensers, VC1, VC2 and VC3. These tune the input energy to the first three tubes. By tuning each of these three circuits to resonance with the incoming signal, that signal will be passed along to the detector and the audio-frequency amplifiers (VT3, VT4 and VT5). If any one of the circuits is out of resonance the passage of the signal will be blocked. The method of tuning will be explained later.

---

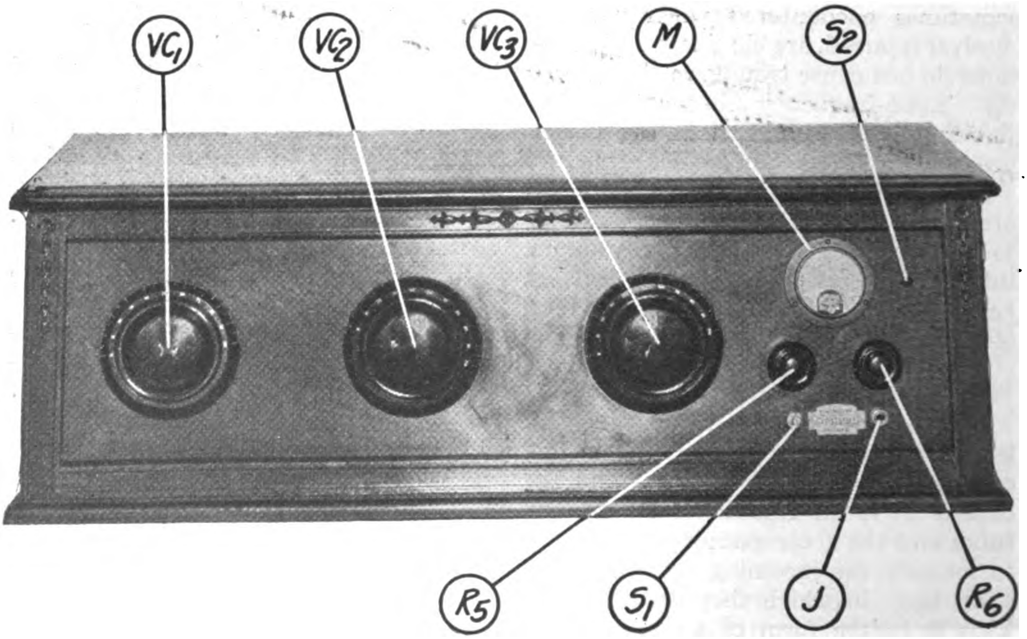
† A more detailed explanation of the amplifier and detector action may be obtained from the previous articles of this series, in the December 1924 and the March, June, August and September 1925 issues.

Antenna and Ground

In localities where there are several local broadcasting stations it will be found that results are generally more satisfactory if a short antenna is used. This may be located out of doors and should be about 60 to 75 feet in length measured along the antenna from the receiver to the far end of the wire, and including both the antenna proper and the lead-in wire. Or it may be erected indoors, strung along the picture moulding or even along the baseboard. The indoor antenna may be anything over 40 feet in length, measured as above, and should preferably be strung continuously in one direction, rather than around two or more sides of one room. It is sometimes possible, for instance, to run the wire from the receiver, across the room and then into a hall where a good straight stretch is available.

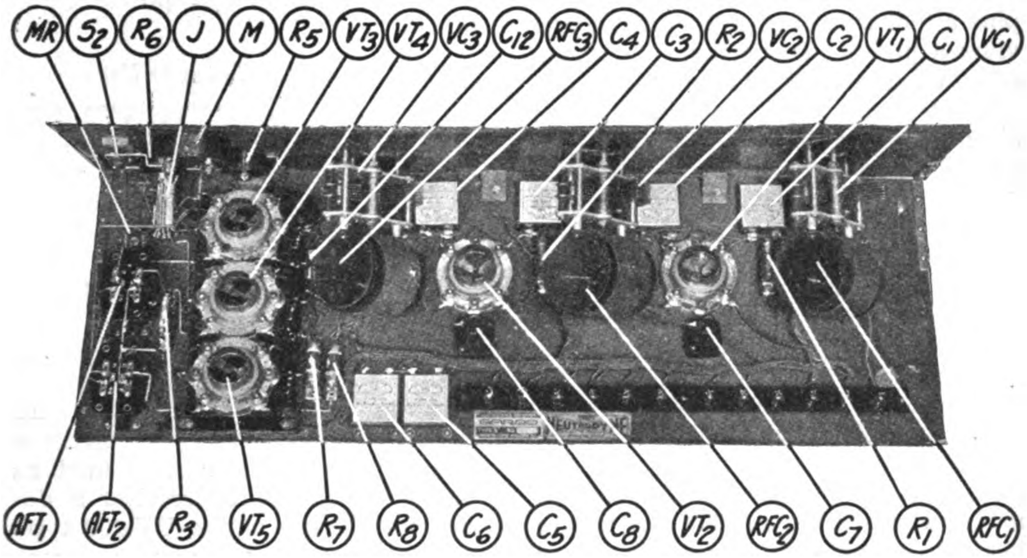
Short antennas such as the above will do much to reduce static interference which is sometimes bothersome in summer. It will also prevent nearby, powerful broadcasting stations from overlapping or interfering with broadcasting from more distant or weaker stations, which operate on nearly the same wavelength. An indoor antenna will prove entirely satisfactory for all local and moderately distant reception. The short outdoor antenna will, as a rule, provide reception from somewhat greater distances than the indoor type.

For reception from great distances a long outdoor antenna up to 150 feet in length is recommended. This should be strung as high above the ground as possible and should be kept well clear of



FRONT VIEW OF THE RECEIVER, SHOWING THE PANEL CONTROLS

FIGURE 2: *Tuning is accomplished by means of the three large dials. The meter at the right normally shows the voltage across the detector filament, which should be maintained at five or lower. This meter may also be used to obtain the voltage reading of the "A," "B" and "C" batteries, as explained in the text. The use of the two rheostat dials, R5 and R6, and of the filament switch S1 and phone jack J, are explained in the text.*



THE RECEIVER REMOVED FROM CABINET

FIGURE 3: *A view of all the instruments is clearly shown here. The designating letters are the same as those used in Figure 1.*

trees or other buildings. Trees especially have a tendency to absorb radio waves and it is therefore advisable to keep the antenna wire at least 10 feet from them and preferably 20 feet.

For the outdoor antenna, long or short, the use of ordinary bare, seven-strand copper antenna wire has proven entirely satisfactory. The insulators should be of high quality. If possible the wire should be purchased in a single length so that no joints are necessary. If it is necessary to make joints, however, they should be clean and well soldered. This applies to joints in the antenna proper and also where the lead-in wire is joined to the antenna. A fair substitute for soldered joints may be made by scraping the wire clean and joining the two ends together by twisting; then wrapping the joint in tinfoil and finally wrapping two layers of rubber tape around the tinfoil.

In the case of an indoor antenna, where it is to be strung along the walls, insulated wire should be used. This may be No. 14 stranded wire or single-conductor insulated wire of the same size. In tacking it up care should be exercised to prevent the tacks from going through the insulation and making contact with the wire. This difficulty can be avoided by using the small insulated staples or double pointed tacks which straddle the wire.

Figure 4 suggests a good arrangement for the outdoor antenna. The method of placing the insulators is clearly shown; also a good way to bring the lead-in wire into the house. The method of connecting the lightning arrester is also given. It is a requirement of the Fire Underwriters that every outdoor antenna be equipped with an approved lightning arrester. In most cases the ground side of the arrester may be connected to the same ground connection as used for the receiver instead of using a separate outside ground connection as shown in Figure 4. In a few localities, however, the insurance companies require that the arrester be mounted and grounded outside of the house.

A good ground connection for the receiver is of much more importance than is usually believed. There are many who believe that simply driving an iron pipe a foot or two into the ground provides a positive connection. Occasionally it does, but more often it does not.

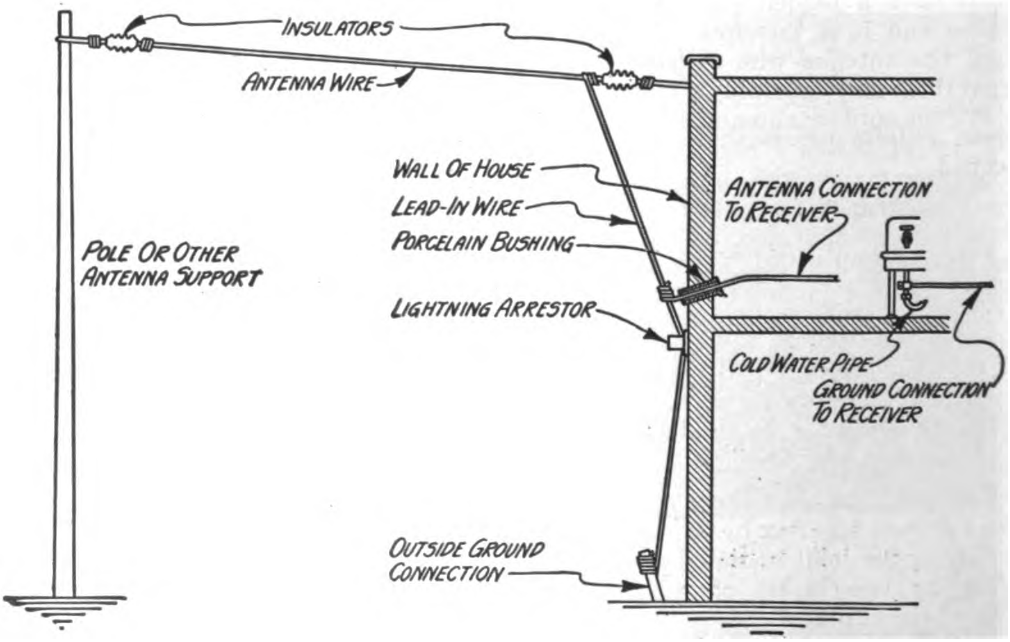
The best all-around ground connection is one made to the cold water pipes, scraped clean at the point of contact. In some cases, however, there may be insulated sections in the pipe line, especially at the water meter, so it is always a good move to bridge a piece of wire across the meter, attaching the ends to the pipe on each side of the meter. For this purpose ground clamps may be used, after the pipe has been filed clean where the clamps are to be attached.

If there is no cold water pipe in the house a good connection can usually be made by suspending a coil of copper wire in a well, or burying a quantity of copper wire several feet underground at a point where the ground is moist. In any case it is advisable to keep the ground lead as short as possible by using the nearest ground connection that proves satisfactory.

The Vacuum Tubes to Use

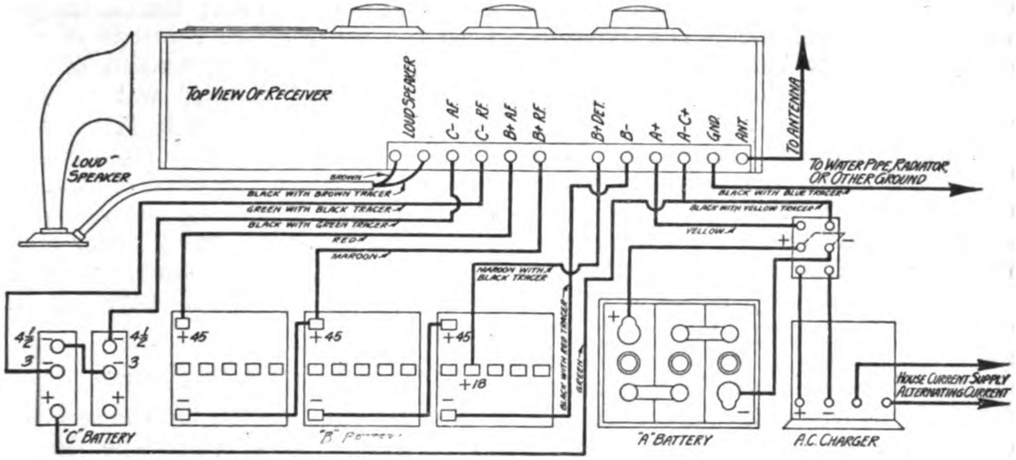
The amplifier tubes, VT1, VT2, VT4 and VT5, are UV-201-a's or C-301-a's. These are so-called "hard" tubes. Many makes of these tubes are now going on the market, some good and some not so good, therefore it is best to stick to standard makes in purchasing the tubes.

For VT3, which is the detector tube, a "soft" tube is used; this may be either the UV-200 or the C-300. In many of the present day receivers a UV-201-a or C-301-a tube is used as detector but the Garod receiver is designed for the use of the UV-200 type tube. The manufacturer has two reasons for the choice of this detector; experimental and development work on this receiver convinced him that the "soft" detector tube lent a mellowness


INSULATORS
ANTENNA WIRE
WALL OF HOUSE
LEAD-IN WIRE
PORCELAIN BUSHING
POLE OR OTHER ANTENNA SUPPORT
LIGHTNING ARRESTOR
ANTENNA CONNECTION TO RECEIVER
COLD WATER PIPE
GROUND CONNECTION TO RECEIVER
OUTSIDE GROUND CONNECTION

AN EXCELLENT ANTENNA ARRANGEMENT

FIGURE 4: *The design of the antenna is necessarily governed, in most cases, by the roof or yard space available. However, many of the ideas suggested by this illustration may be used to advantage in any antenna installation. The best length for the antenna will depend in each case on the interference conditions.*



HOW TO CONNECT UP THE RECEIVER

Figure 5: *Here all the external connections are shown; also a convenient battery charging arrangement. When the double-pole, double-throw switch is thrown up the storage battery is connected to the receiver. To charge the battery it is necessary merely to throw the switch down and the battery is thus connected to the charger. The charger plug is then inserted in the alternating current house lighting socket. When the house supply is direct current the charger connections used are those shown in Figure 6.*

to the tone quality of the receiver which was not obtainable with the "hard" tube and secondly, he found the UV-201-a type of tube to be less sensitive to weak signals from distant stations.

There is no question but that the UV-200 works out very well in this receiver and its use is therefore recommended.

What Batteries to Use

Three types of batteries are used with the Garod receiver. First there is the 6-volt "A" battery to light the filaments of the vacuum tubes; then there is the high-voltage "B" battery to supply the necessary plate current, from which the power for the amplified signals is obtained. And finally, there is the low-voltage "C" battery which provides the proper "bias" to the grids of the audio-frequency amplifier tubes to produce the best tone quality in the amplifier and at the same time conserve the current of the more expensive "B" batteries.

The 6-volt "A" battery must be of the storage type. Any of the standard makes of radio storage "A" batteries will serve this purpose and should have a capacity of not less than 100-ampere-hours.

The "B" batteries may be of either the dry-cell or storage type. Either will give satisfactory results. The table below shows the approximate life of dry-cell "B" batteries under different conditions of service.

The "C" battery is a small battery unit made up of three flashlight cells in a single block, having a total voltage of 4½-volts. For "C" battery voltage higher than 4½-volts two of these blocks may be connected in series, thus providing for potentials up to 9 volts. The current consumption from this battery is practically nil and for that reason there would be no advantage in using a storage battery here. The life of this battery should be a year at least, regardless of how much daily use the receiver is subjected to.

The storage "A" battery needs little attention. It will need an occasional charge and for this purpose a battery charger may be purchased in any radio store. This is a device which permits charging the battery from the lighting circuit. It is first essential to determine whether the house supply is alternating or direct-current because the type of charger needed will depend on the kind of house supply current.

Another necessary accessory is a hydrometer, which is an instrument used to measure the state of charge of the storage "A" battery. It is an inexpensive glass instrument with a rubber bulb on one end by means of which some of the electrolyte (liquid solution) from the battery is drawn up into a chamber in which there is a calibrated float. It is from the point on the calibrated scale at the top of the solution that the reading is taken. A reading of 1,285 indicates a fully charged battery while a discharged battery will register approximately 1,150. When the reading drops to 1,185 the battery should be recharged at once as allowing further discharge is likely to injure it. A fully charged storage battery with a capacity of 100 ampere hours should operate this receiver for approximately 40 hours before recharging becomes necessary. The current drain of the receiver is about two amperes per hour and the life of a single charge should theoretically be 50 hours but as stated before, it is not advisable to run a battery down completely.

About once every month or two a little distilled water should be added to each of the three cells of the storage battery, in order to keep the electrolyte level somewhat above the tops of the plates. The electrolyte consists of sulphuric acid and distilled water. The acid does not evaporate, however, and therefore does not need replacement as does the water. A word of caution should be given here against allowing any of the electrolyte to spill over onto the floor or clothing because the acid will leave its mark on anything it touches.

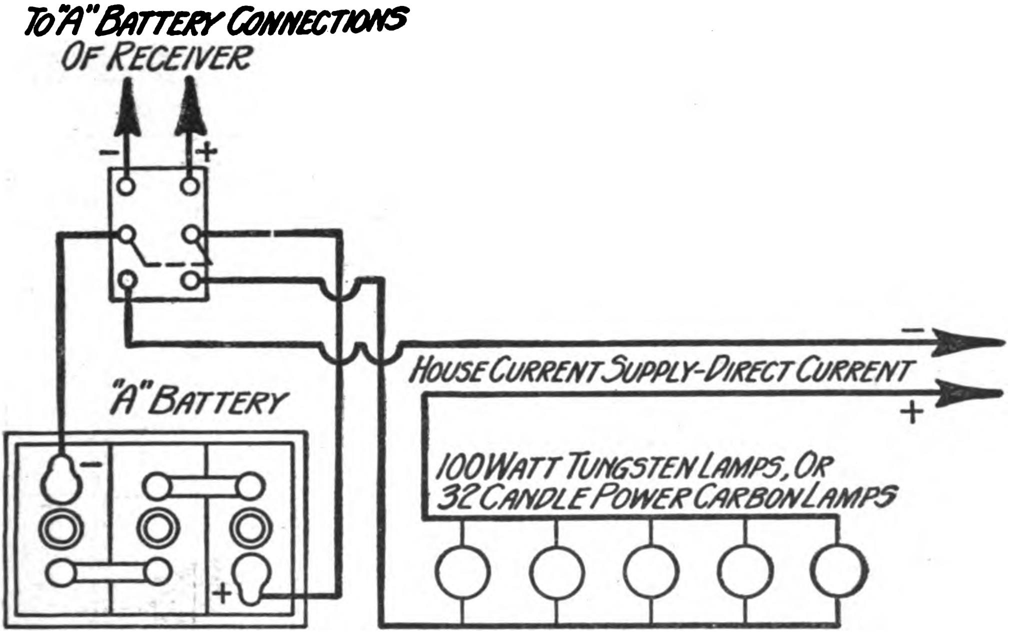
How to Operate the Receiver

For use in connecting up the receiver to batteries and antenna the Garod Company have available a connection cable containing a sufficient number of wires for all connections to the receiver. Each of these wires is of a different color so that the proper leads are easily distinguishable. The complete connections are shown in Figure 5 and in each case the color of the wire is noted. An "A" battery charger has been shown in the diagram, with a double-pole, double-throw switch for disconnecting the battery from the receiver and connecting it to the charger. With this arrangement it is never necessary to disconnect the leads from the "A" battery. To charge the battery the plug from the charger is inserted in a convenient alternating-current, house-lighting fixture and the switch is thrown to the side from which wires lead to the charger. When

TABLE OF ESTIMATED "B" BATTERY LIFE WITH GAROD RECEIVER

Receiver Used hours per day	*2 hours*	*3 hours*	*4 hours*
Batteries 1 and 2	154 days	96 days	63 days
Battery 3......	200 days	130 days	92 days
3 batteries interchanged weekly	166 days	106 days	72 days

The above estimates are based on the battery voltages specified in this article, and assuming that the loudspeaker is used and volume is kept at maximum at all times while receiver is in operation. The current drain from the first 90 volts of "B" battery will be higher because it supplies both the radio and audio-frequency-amplifier tubes, while the other 45-volt battery supplies only the audio amplifier. To even up the wear on the batteries, therefore, it is well to interchange them once a month, putting the third where the first was before, the first where the second was before, and so on.


TO "A" BATTERY CONNECTIONS OF RECEIVER
-
+
"A" BATTERY
-
+
HOUSE CURRENT SUPPLY-DIRECT CURRENT
-
+
100 WATT TUNGSTEN LAMPS, OR 32 CANDLE POWER CARBON LAMPS

CONNECTIONS FOR CHARGING "A" BATTERY FROM D.C. HOUSE SUPPLY

FIGURE 6: *The type of battery charger used depends on the kind of house supply current. If it is alternating current, a regular A.C. charger is used. If the house supply is direct current, however, a simple arrangement of electric lamps is used as shown here. If preferred a D.C. battery charging resistance may be used instead of the lamps.*

the charge is completed it is only necessary to pull the charger plug from the lighting socket and throw the switch to the side from which wires go to the receiver. This arrangement is not only convenient, but is absolutely fool-proof as it is impossible to have the battery connected to the charger and the receiver at the same time, a condition which would in all probability result in burned-out tubes.

It must be borne in mind that this arrangement applies only where the house supply is *alternating current*. For charging a battery from a *direct-current* house supply the charger may consist of simply a bank of five ordinary 100-watt lamps. Connections are shown in Figure 6.

Assuming that the five tubes have been placed in their sockets and the receiver is all connected as shown in Figure 5, it is ready to put into operation. The two knobs, volume and detector control should first be turned as far as possible in a counter-clockwise direction. Then the battery switch knob is pulled out. The tubes in sockets VT4 and VT5 should now light up. Next turn the volume control in clockwise direction until the tubes in sockets VT1 and VT2 are lighted to the same brightness as the audio-frequency amplifier tubes. Then turn the detector control knob in clockwise direction until a faint hissing sound is heard in the loud-speaker, and turn it back again until the hissing has just stopped. This will be the most sensitive point of adjustment for the detector. The detector tube will light up much more brilliantly than the other four tubes.

As the detector control is adjusted it will be noticed that the hand of the meter will move. As a rule the hissing sound will start when this hand has reached about 4½-volts on the lower scale of the meter dial. The control should never be turned sufficiently far to bring the meter hand past 5-volts,

TUNING CHART OF GAROD NEUTRODYNE RECEIVER

Station	*Wavelength*	*Dial No. 1*	*Dial No. 2*	*Dial No. 3*
KDKA	309	43	41	40
KYW	535	94	89	89
WAAM	263	28	27	28.5
WAHG	316	44	43	42
WCAE	461	77	73	73
WEAF	492	84	80	80
WEBJ	273	33	31.5	31
WEEI	476	81	77	77
WGCP	252	25	24	25
WGY	380	60	57	56
WHN	360	56	53	52
WLIT	395	64	60	60
WLW	422	69	65	65
WMCA	341	51	49	48
WNYC	526	91	86	87
WOKO	233	12	14	16
WOO	508	87	83	83
WOR	405	64	61	61
WOS	441	73	69	69
WPG	300	40	39	38
WRC	469	79	75	75
WRNY	259	27	26	27
WTAM	390	62	58	57

otherwise the tube will last only a short time.

At first when tuning in a broadcasting station it is advisable to use headphones, which should be plugged into the jack at the lower, right-hand corner of the panel. When this is done the light in VT5 goes out. This is due to the automatic filament control feature of this jack which cuts off the filament-supply current to this tube, inasmuch as only four tubes are used with the headphones.

The actual tuning of the receiver to bring in broadcast programs is accomplished by turning the three dials slowly and in unison. It is well to start with the three dials set at any number, say 40. If nothing is heard, turn them each to 42, then on to 44, and so on. In this way it will not be long before some broadcasting is heard. Each of the three dials is then adjusted separately to the point where the signals come in with sufficient volume. It may be that the three dials will not be set exactly alike, perhaps having a difference of one degree or so. This is especially true of the left-hand dial, the setting of which varies slightly according to the length of the antenna.

With this first station tuned in, readjust the volume and detector knobs. The best setting is the lowest one that will produce sufficient volume and maximum clarity. If these knobs (one at a time) are turned all the way off (counterclockwise) and then turned slowly clockwise, the volume of signals will increase steadily up to a certain point, after which there will be no increase in signal strength. This is the point at which to leave these controls set. If turned higher both tube and battery life are wasted.

The next move is to try various "B" battery voltages on the detector tube. In Figure 5 the connection is shown at 19½ volts. Move this to the 18-volt tap of the "B" battery, then try 16½, then go up to 21, etc. One tap will usually give better results than the others, and this is the tap to which the wire should be left connected. It is advisable to slightly readjust the detector control knob after each change in "B" battery voltage during these tests, to keep it at the point of maximum results. This point varies some with variations of the "B" battery voltage.

If desired, more, or less, "B" battery voltage may be used on the audio-amplifier (although 90 volts should always be used on the radio frequency amplifier tubes). Tests have demonstrated, however, that 135 volts is best for ordinary conditions and it is recommended that this be the voltage used. This also applies to the "C" battery. In this case 3-volts has been found best for the radio-frequency amplifier and 6-volts for the audio-frequency amplifier. These are the voltages shown connected in Figure 5. So far as tone quality and volume are concerned 4½ or even 3-volts of "C" battery on the audio-frequency amplifier will give practically the same results as 6 volts, but the higher "C" battery voltage increases the life of the "B" batteries materially.

How to Chart the Receiver

As each new broadcasting station is tuned in an accurate record of the settings of the three dials should be kept. After twenty or thirty stations have been tuned in and recorded they may be transferred to another piece of paper and arranged in alphabetical order according to call letters. Thus when it is desired to tune in any particular station it is only necessary to consult this chart for the dial settings for this station and set the dials accordingly.

American Legion

OLD DOCTOR RADIO CHEERS UP OUR DISABLED SOLDIERS

In this ward of the Walter Reed General Hospital in Washington, D. C., the beds have been furnished with headsets that enable each patient to listen in as he desires. The radio equipment was furnished by the New York Sun-Roxy Radio Fund, in collaboration with the American Legion.

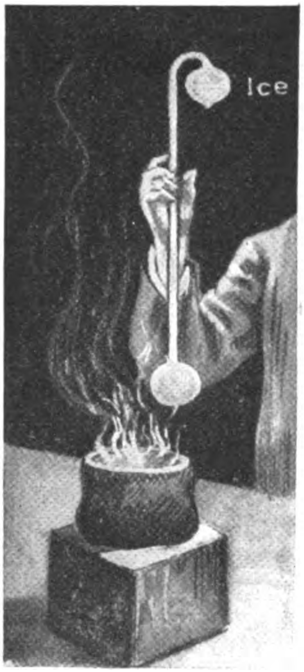
The ATOM

ARTICLE NO. 3

The Nature of Liquids

Scientists tell us that the entire universe is made up of only ninety different kinds of atoms. Tremendous power is believed to lie within these minute and constantly moving particles. To solve the age-old mysteries that lurk within them and to harness their energy has now become one of science's greatest problems.

By SIR WILLIAM BRAGG,
K.B.E., D.Sc., F.R.S., M.R.I.



THE "CRYOPHORUS" EXPERIMENT
FIGURE 1: *The two glass bulbs, together with the connecting tube, contain only water—with no air. When the lower bulb is emptied of water and immersed in liquid air, the water in the upper bulb freezes.*

THE difference between a gas and a liquid is that in the former the atoms and molecules move to and fro in an independent existence, whereas in the latter they are always in touch with one another, even though the touch is transient and they change partners continually.

Heat is required to make a liquid turn into a gas, because the molecules must be given greater energy to enable them to break away from one another; we see this when the wet street dries in the sunshine. Sometimes it may seem that there is no supply of heat when a liquid evaporates, but there must be a source somewhere, though it may be unnoticed.

For instance, the supply may come from the liquid itself, which becomes colder in consequence. The way in which this takes place is quite simple. The molecules in the liquid are in motion, vibrating, turning, shifting their positions. At the surface there are always some that are for the moment more energetic or less lightly held than their fellows, and these may part company and be flung off into space. It is, on the whole, the more energetic that go, so that the average energy of the remainder is reduced. This is equivalent to saying that the temperature of the remainder is lowered.

Cooling by evaporation is a familiar effect. When our hands are wet, they feel cold because of the evaporation of the water. The surgeon may use an ether spray when he wants to cause a local freezing; nature cools our bodies by the same principle, but in a gentler fashion. In hot dry countries, drinking-water is cooled by putting it into a porous canvas bag, so placed that it is shaded from the sun but exposed to the wind, and the hotter the wind the better.

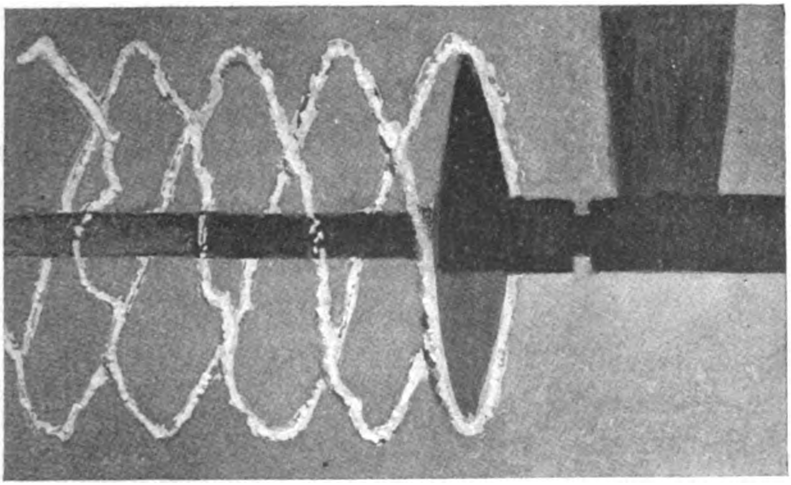
The experiment of the cryophorus (Figure 1) illustrates the point very well. The two bulbs and the connecting tube contain only water, no air. The water is brought to the upper bulb; the lower, which is empty, is immersed in liquid air. In a surprisingly short time the water is frozen solid. The explanation is that the water molecules which fling themselves from the surface of the water make their way in large numbers down the tube and so to the lower bulb. This would happen anyhow, whether there was or was not liquid air round the lower vessel; but if there were none they would come back again and return to the water carrying their superabundant energy with them. The liquid air cools the walls of the lower vessel, and they in turn cool the molecules that strike them, so that they stay there, and their energy is never restored to the water.

When a liquid boils in the open air, the molecules leave the surface at such a rate and with such energy that they push back the air *en masse;* in evaporation, the molecules leave one by one and must make their way as individuals through molecules of the air.

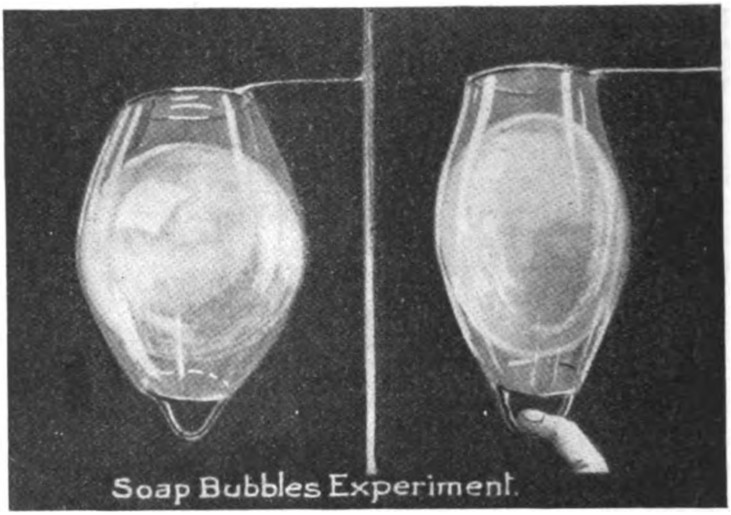
The forces that bind molecule to molecule in a liquid are very great indeed. In a drop of water that hangs from one's finger the molecules cling to one another like the bees in a swarm that hangs from a tree. But this gives a very feeble idea of the magnitude of the forces that can be exerted. It is well known that a liquid strongly resists compression; it is not known so generally that it strongly resists extension also.

Curiously enough, the effect known as water-hammer is met with in a case where it has caused great concern and monetary loss. When screw steamers began to be turbine-driven, the screws were found to be eaten away as if attacked by some powerful acid. The cause was at last traced to the formation of empty spaces in the water; the screws moved so fast that the water could not follow them. Especially did this happen near the tips of the blades. The drawing in Figure 2 is from a photograph taken in the Turbinia Works; a model screw is turning in a tank, and the water flowing past it contains a series of cavities in the form of spirals. When these cavities collapse the shock is really severe, and if any part of the blade happens to form part of the cavity wall the blow may tear away a portion of the metal.

Since every molecule in a liquid has some attraction for every other, there is a general tendency to move so as to



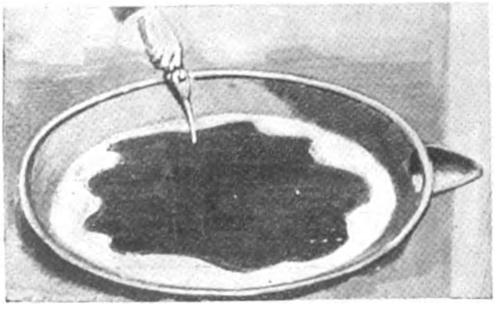
THE DESTRUCTIVE EFFECT OF A "WATERHAMMER" ON A SHIP'S SCREW
FIGURE 2: *When the spiral cavities, formed in the water by the action of a revolving screw, collapse, the shock is so severe as to damage the metal that may come in contact with it.*



AN EXPERIMENT WITH SOAP BUBBLES

FIGURE 3: *Here is a soap bubble blown within another bubble. So long as the drop of water on the bottom of the inside bubble does not touch the outer bubble, the two will not coalesce, even though the outside bubble is distorted as shown.*

give each molecule as many neighbors as possible. Any separate portion of a liquid, therefore, tries to gather itself into a sphere. So raindrops try to become round, and so do drops of molten lead as they fall in a shot-tower. Mercury gathers itself into drops when it is spilled upon the table, and the smaller the drops the more nearly they approach to the spherical. The liquid behaves as if it had an outside layer which resisted being stretched; it has to have the smallest possible amount of surface. This is very well seen in an experiment with the liquid toluidine. The dark-looking liquid, toluidine, does not mix with water, and its density is such that it floats conveniently in the middle of a vessel containing a layer of pure water riding on a layer of salt water. The liquid gathers itself together into a large drop, which takes a spherical form. If disturbed by a glass rod it wobbles heavily through a variety of remarkable shapes.



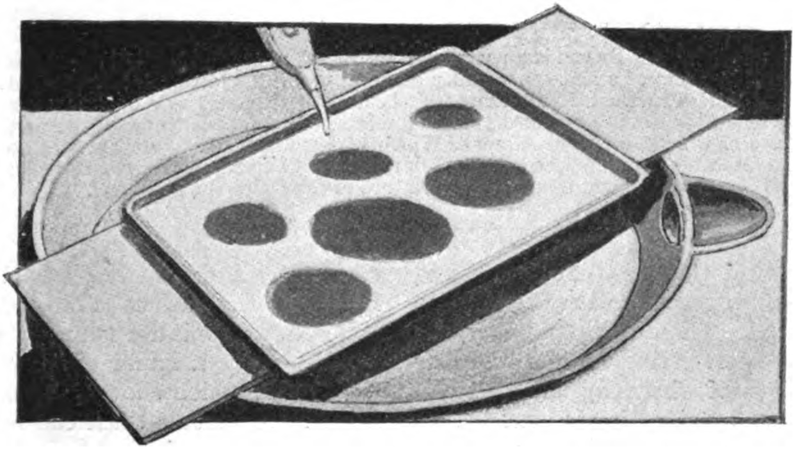
HOW OIL CLEARS THE WATER OF POWDER

FIGURE 4: *A few drops of oil dropped upon the surface of water covered with powder will instantly cause the powder to arrange itself outside of the rim of oil.*

When a glass plate is forced to the bottom of the mercury in a dish, it does not rise again—in fact, it requires considerable force to release it. The reason is that the mercury will not make its way under the plate, because in doing so its atoms must be spread out, against their desire to herd together.

Very interesting cases arise when certain molecules are put into water—as, for example, when we make a soap solution.

In soap there are many molecules of a very peculiar form, which we shall be able to examine more closely when we come to consider the action of X rays.



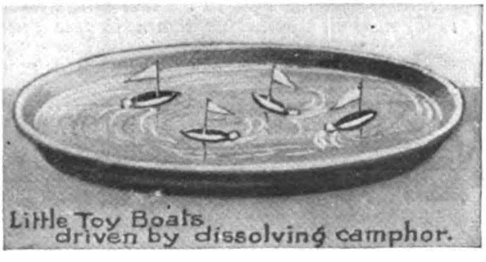
THE AREA OF A DROP OF OIL ON WATER

Figure 5: *When drops of oil are put upon water covered with powder, small circles are cleared; the sizes show how much of a layer one-molecule-thick can be covered by the oil that is put on.*

Their length is very long compared to their width. The central part is a zigzag chain of carbon atoms, and at each end there are what we may call finials, consisting of certain special atomic groups. One of the finials has a strong attraction for water, and the other has not. The consequence is that, whenever these molecules arrive at the surface of the soapy water in the course of their wanderings, they take up an arrangement in which that finial which has the attraction for water is directed inwards, and the other finial is on the outside.

However, the molecules have a certain attraction for each other which prompts them to line up side by side. The consequence is that a special film of these molecules forms all over the water, the molecules standing at right angles to the water surface in which they are rooted. It reminds one of a row of policemen linked arm in arm to hold back a crowd. Such a film resists rupture, and may exert remarkable powers of holding together its content of water and soap. We use this principle whenever we blow a soap-bubble; the thin wall of the bubble has a film both inside and out, and when we stretch the bubble, more of the molecules slip out of the liquid and take their places in these films.

Some years ago Mr. C. V. Boys showed in a lecture-room a long series of beautiful experiments on soap-bubbles. In one of them, which is illustrated in Figure 3, he blew one soap-bubble inside another, and, withdrawing his pipe, allowed the second to rest gently within the first. He showed that at first it was necessary to extend the outer bubble by attaching a small weight at the bottom, in the manner shown in the figure. There is then a circle of contact between the two bubbles; the drop on the bottom of the inside bubble does not come into contact with the outer. If it did there would be a col-


Little Toy Boats driven by dissolving camphor.

BOATS DRIVEN BY CAMPHOR

Figure 6: *A small lump of camphor fastened to the stern of a miniature boat propels it slowly through the water, due to the chemical action.*

"The Atom and the Nature of Things"

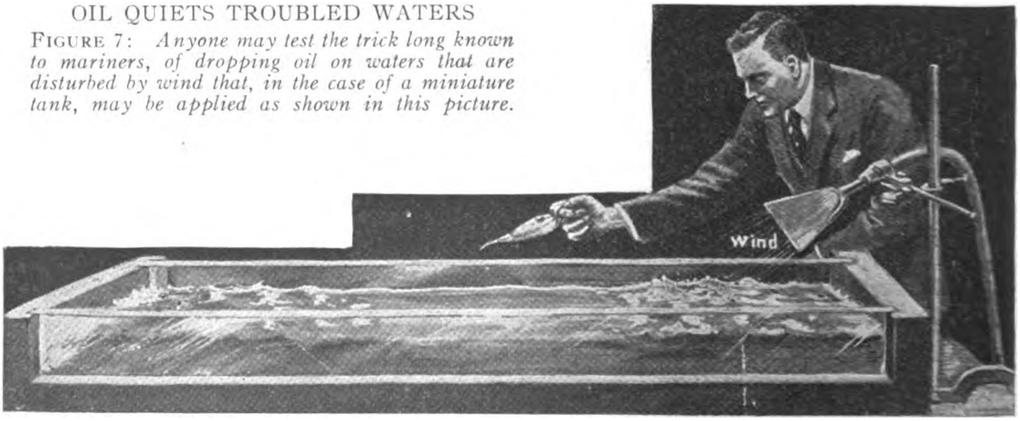
Sir William Bragg is a pastmaster in the art of expounding the mysteries and wonders of science to popular audiences, and his lectures at the Royal Institution in England fascinated his hearers, both young and old. He has written for **Popular Radio** special abridgments of the six lectures, the first two of which—on "The Atoms of Which Things Are Made" and "The Nature of Gases"—were published in our issues of August and September respectively. The next article will treat of "The Nature of Crystals: the Diamond."

---

lapse, because the two bubbles would actually join together and try to become one bubble. These things may be explained by referring to the peculiar arrangement of the long chain molecules. The outside is in each case a sheet of the finials which have so little attraction for water—and, indeed, for each other. Consequently, when two bubbles seem to touch, the outside sheet of one has no attraction for the outside sheet of the other and there is no desire to coalesce. One bubble can be pressed against the other without harm, or rest on the other, as in the illustration. But the drop of water would form a link. When it is carefully drained away, there is no longer any need to pull the outer bubble out of shape.

If we put a drop of oil on water, the long chain molecules of the oil at once arrange themselves side by side on the outside of the water, one end of the molecule rooted in the water and the other in the air. The action is extraordinarily prompt. If the surface of a sheet of water (Figure 4) is covered with a powder, and a little oil is allowed to fall on it, the surface is cleared at once. When a very minute quantity is put on to the water a small circle is cleared, the size of which shows how much of a layer one-molecule-thick can be covered by the amount of oil put on (Figure 5). When camphor is dissolved in water, the solution spreads at once, and in so doing exerts a back pressure on the fragment of camphor. Hence the wrigglings and twistings of the fragments of camphor thrown on water—a very old experiment. A little lump of camphor fastened to the stem of a miniature boat propels it slowly across the water; in the experiment illustrated in Figure 6 a small flotilla went through various evolutions.

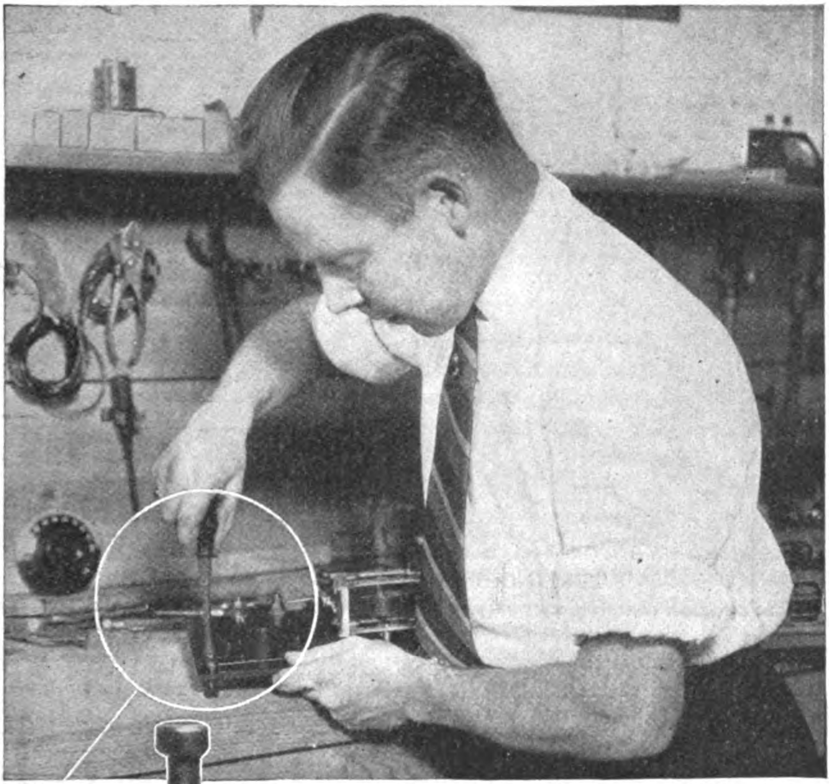
An oil film seems to offer no opportunity to the wind to raise waves. The air blast in Figure 7 (a vacuum cleaner used as a blower) caused a series of ripples to run along the tank, which were stilled at once when a drop of oil was let fall. When the oil film had been blown away the ripples began again.



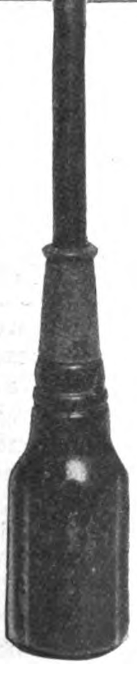
OIL QUIETS TROUBLED WATERS

FIGURE 7: *Anyone may test the trick long known to mariners, of dropping oil on waters that are disturbed by wind that, in the case of a miniature tank, may be applied as shown in this picture.*

Handy Tools for Radio Fans: No. 8



From a photograph made for POPULAR RADIO



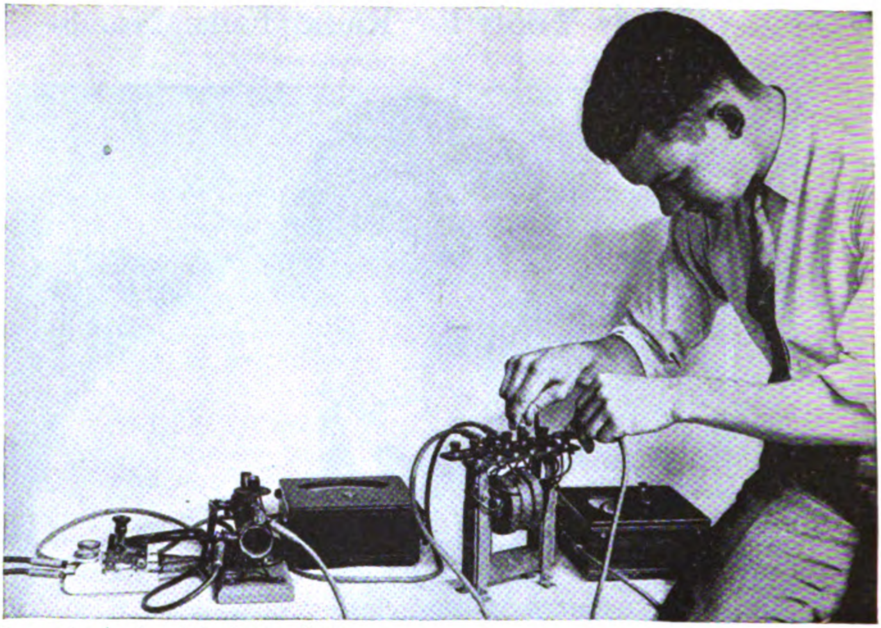
THE SOCKET WRENCH

A useful device for tightening nuts

WHERE it is necessary to tighten bolts and nuts of various sizes in a radio set—especially where it is impossible to use an ordinary wrench—the socket type of wrench as shown in this picture is extremely handy.

The wrench is made up similar in appearance to a screw-driver. But it contains a socket for either hexagon or round nuts. This is a useful tool for the amateur experimenter and set builder to have on hand for keeping all the terminals in his set secure and tight to insure good connections. Many times the trouble in a receiving set is through faulty terminal contacts due to loose threads on the screws or bolts that make connections.

The preceding suggestions in this series were SIDE-CUTTING PLIERS, SCREW-DRIVERS, THE HYDROMETER, THE BATTERY-TESTING VOLTMETER, THE FILE, THE JACK KNIFE *and* THE ELECTRIC SOLDERING IRON.



From a photograph made for POPULAR RADIO

TESTING THE FINISHED TRANSFORMER

The electrical characteristics may be checked up with a voltmeter and an ammeter before it is placed in actual service—as the author is here doing.

PRACTICAL POINTERS ABOUT

TRANSFORMERS

What they are, how they work, and how they are designed and built—together with construction details for the radio experimenter.

By F. E. NIMMCKE, E.E.

THE day is fast approaching when the "A" and "B" batteries will no longer be used in connection with radio sets. Where the house current is available, there the required voltages to operate the set will be obtained by plugging into the light socket just as though it were an ordinary household appliance.

Direct current and alternating current are conveniently adapted to radio purposes because of the small amount used and the small maintenance cost of the necessary equipment. Several articles describing the construction of "A" and "B" eliminators and storage battery charging devices using alternating current have appeared in print; in conjunction with these devices, transformers are used either to step up or step down the supply voltage. This flexibility of alternating current facilitates its use.

In the printed articles on the subject, the types of transformers used are usually of a specified make; they are not designed or constructed. Yet the radio enthusiast would get as much pleasure out of designing and constructing a transformer as he would in making a set. The lack of knowledge as to what it does, how it is designed, and how it is constructed, is his greatest drawback.

In this article is given the necessary data to design and construct transformers for voltages and capacities that are ordinarily encountered in radio work. The mathematical complexities have been reduced to the simplest forms requiring only a good knowledge of arithmetic.

Before proceeding with the design of a transformer, it is well to give a brief theory of its operation:

A transformer is an alternating current device which converts electrical energy at one potential to energy at a higher or lower potential. It consists chiefly of three parts:

(a) The iron core;
(b) The primary winding;
(c) The secondary winding.

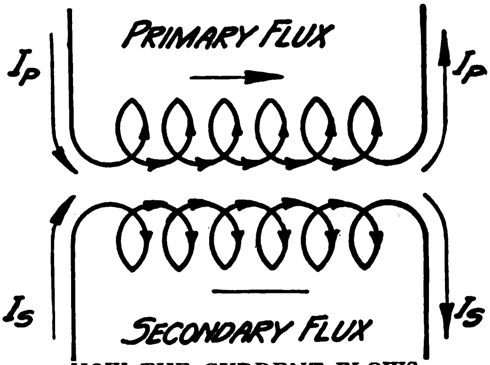
The iron core is the magnetic link between the primary and secondary windings and forms a low resistance path for the magnetic lines of force. The primary winding receives energy from the supply line, while the secondary winding receives the induced energy and delivers it to the secondary external circuit.

The operation of the transformer depends upon the theory of mutual induction. When an alternating voltage is impressed upon the primary winding of a transformer, an alternating current flows. At no load (that is, with the secondary disconnected from its external circuit), one component of this current known as the "magnetizing component" sets up a magnetic field or flux about the primary winding. This flux, by virtue of self-inductance, sets up in the primary winding a counter voltage which is nearly equal to the impressed voltage. The difference between the impressed voltage and the counter voltage is known as the effective voltage, as it causes the primary current to flow.

This flux about the primary winding and through the iron core also cuts the turns on the secondary winding thereby inducing in it a voltage. In rotating machinery, such as an alternating current generator, the conductors or turns cut a stationary flux, whereas in the transformer the flux cuts the stationary conductors producing the same result. When the secondary winding is connected to an external load, such as the filaments of vacuum tubes, a current will flow in the secondary winding. This current creates a flux opposite to the primary flux, as shown in Figure 1.

The secondary flux tends to decrease slightly the primary flux, and in so doing it reduces the counter voltage, thereby increasing the effective voltage and hence more current flows in the primary. This operation is automatic and depends upon the secondary load. The tendency of this action is to maintain the primary flux and the primary counter voltage practically constant.

The voltage induced in the secondary will depend upon the number of turns that are cut by the primary flux. That is to say, if the primary has 100 turns and the secondary 10 turns, then 100 volts impressed upon the primary would give a result of 10 volts at the secondary terminals. This is a "step-down" transformer and shows that the voltages of the primary and secondary are directly proportional to the number of turns in the windings. If this same transformer is used again, but this time the 10-turn winding is the primary and has



HOW THE CURRENT FLOWS

FIGURE 1: *This drawing shows how the current in the primary sets up a current in the secondary of the same frequency, but of a voltage depending on the turns ratio.*

impressed upon it 10 volts, then 100 volts would result at the terminals of the 100-turn or secondary winding. This is a "step-up" transformer. The ratio of the secondary voltage to the primary voltage is known as "the ratio of transformation" and may be expressed by r.

r = secondary voltage/primary voltage. (1) If r is greater than 1, it is a step-up transformer; and if r is less than 1, it is a step-down transformer. The primary side of a transformer is that side to which the voltage is applied; it may have a large or a small number of turns—this is irrelative to the term "primary." The secondary side is that side to which the output load is connected.

In general there are two classes of iron-core transformers:

(1) The core-type;

(2) The shell type.

The chief distinction between these two types is the arrangement of the coils with respect to the core. In the core type the iron core is embedded in the coils and the external surface of the coils is exposed throughout, while in the shell type the coils are partly embedded in the iron core which forms a shell around them. The two types are shown in Figure 2.

The simpler of the two for amateur construction is the core type. As single phase alternating current is commonly used in house lighting from which radio sets are operated, this article will deal with single phase core type transformers.

In design work the designer must use his judgment as to the application of theory to practice. Many design values are assumed and the calculated results must be adjusted to make the construction practical. The design procedure following is self-explanatory, and with a little judgment on the part of the designer, excellent results will be obtained.

Before the actual design is started, the requirements or specifications of the transformer must be known. These are:

(1) The capacity or output of the transformer;

(2) The frequency of the supply voltage;

(3) The primary or supply voltage;

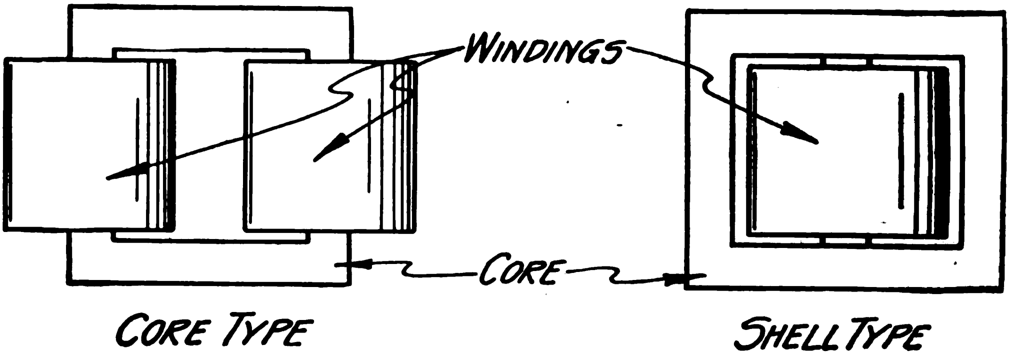
(4) The desired secondary or output voltage.

To facilitate design calculations, the output is assumed to equal the input, since the losses in a transformer are very small.

The output of the transformer is calculated from the current that must be supplied by the secondary, and from the desired secondary voltage. It is the product of the voltage and current expressed in volt-amperes.

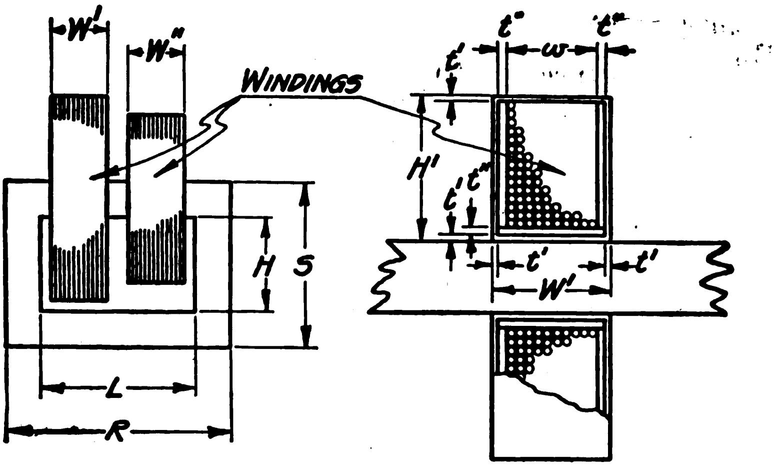
$$P = E \times I \qquad (2)$$

where P is the output in volt-amperes,



TWO TYPES OF CONSTRUCTION

FIGURE 2: *At the left is shown the regular square core type of transformer with the primary and secondary coils wound on opposite legs. At the right is the shell type, in which two legs of the core surround the primary and secondary windings which are both wound one over the the other on the middle leg.*



THE GENERAL DESIGN OF THE WINDINGS

Figure 3: *These drawings give the general designations for the various dimensions of the coils to be figured, and the design for mounting the coils on the core.*

E is the secondary voltage, and I is the output current. If the transformer is to light the filament of, say, 3 UV = 201-a tubes, then the required transformer capacity is as follows: Each tube draws 0.25 ampere at 5 volts, hence the total current is 3 x 0.25 = 0.75 ampere at 5 volts; therefore, the output is 5 x 0.75 = 3.75 volt-amperes. The input also is 3.75 volt-amperes. Assuming that the supply voltage is 110 at a frequency of 60 cycles, then the primary current is the input divided by the supply voltage, or P/E—3.75/110 = 0.034 ampere. The values known thus far are: primary and secondary voltages, primary and secondary currents.

The next step is to determine the number of turns from the general formula

$$N = \frac{E \times 10^8}{4.44\,B\,A\,F} \qquad (3)$$

where N is the number of primary turns, E the primary voltage, B is the flux density or magnetic lines of force per square inch of core area, A is the net core area in square inches, F is the frequency of the supply voltage, 4.44 and 10^8 are constants. The constant 10^8 is expressed as 100,000,000. The primary voltage is known. The flux density, B, is assumed from values ranging from 50,000 to 80,000 lines per square inch of core area, a good average is 60,000 lines per square inch. The core cross-section for this type of transformer may be assumed from areas ranging from 0.5625 to 2.25 square inches. The net area, A, is obtained by multiplying the assumed area by 0.9 (for 0.014 inch iron) which makes allowances for oxide coating or other insulating material placed between the core punchings. It is convenient to use square cores which facilitate not only the construction but also the winding of the coils. For instance, a core area of 0.5625 sq. in. will mean a core 0.75 inch wide and 0.75 inch deep. In order not to have an excessive number of turns, the values of B and A should be large, yet within the above limits. Here again the designer must use his judgment.

To determine N, the known values and the assumed values are substitued in formula (3). The known values in the example are:

$$E = 110; \; F = 60.$$

The assumed values are:

$$B = 60{,}000; \; A = 1.56 \times 0.9 = 1.40$$

hence,

$$N = \frac{110 \times 100{,}000{,}000}{4.44 \times 60{,}000 \times 1.40 \times 60} = 491.5 \text{ turns}$$

Since a half turn is inconvenient, the number of primary turns are 492. The secondary turns are determined by multiplying the primary turns by the transformation ratio obtained from formula (1). In this example r = 5/110 = 0.045. Multiplying 492 by 0.045 there results 22.14 turns. Adjusting the primary turns to 500 and the secondary turns to 24, the ratio will be 24/500 = 0.048. This ratio will give a secondary voltage of 110 x 0.048 = 5.28. This is satisfactory because it is better to have the voltage a little higher than too low.

The size of wire to be used is next determined. The current density which is the amperes per square inch of copper cross-section, may range, for this small type of transformer, from 1,200 to 2,500 amperes. The size of wire best suited for radio work ranges from No. 18 B.S. Gage to No. 28 B.S. Gage D.C.C. Either No. 22 or No. 24 B.S. Gage wire can be used for the filament current winding, depending upon the number of tubes, whereas No. 26 or No. 28 B. S. Gage wire can be used for the plate current and primary windings. Of course smaller wire could be used but the mechanical strength must also be considered. The size of wire for each winding can be determined by dividing the current in the winding by the copper cross-sectional area in square inches of the wire. The formula is

$$D = \frac{I_w}{A_w} \text{ amperes} \qquad (4)$$

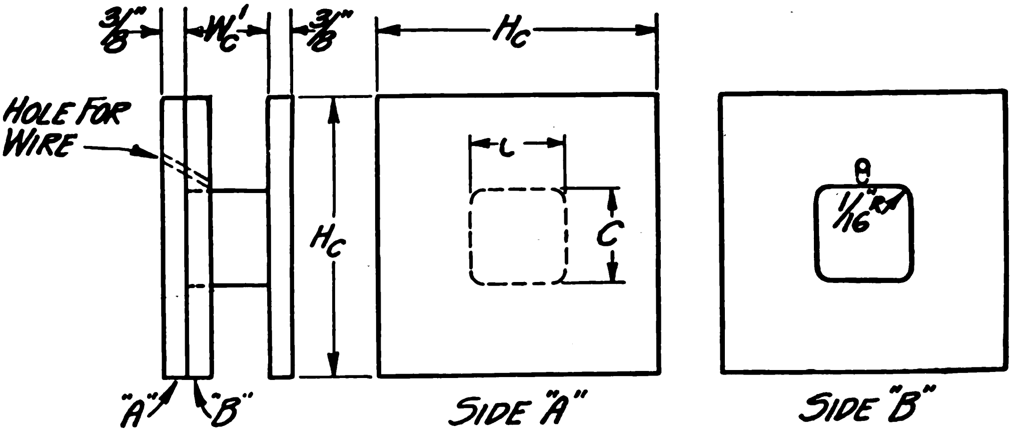
where D is the current density, I_w the current in the winding, and A_w is the cross-sectional area of the wire. The value of D must lie within the limits stated. In the example, let the primary consist of 500 turns of No. 26 B.S. Gage D.C.C. wire and the secondary of No. 24 B.S. Gage D.C.C. wire, then the current densities are

$$D_p = \frac{0.034}{0.000201} = 169 \text{ amperes}$$

$$D_s = \frac{0.75}{0.000314} = 2{,}388 \text{ amperes}$$

The high secondary current density is permissible because of the comparatively few turns in the winding.

The last item to be determined is the size of the iron core punching. This punching should be of the "L" shape because of the ease with which the core can be assembled. The primary and secondary windings should be arranged according to layers and turns per layer. If the primary or secondary winding has a very large number of turns, it is best to split the total number



THE DIMENSIONS OF THE WINDING FORMS

FIGURE 4: *By referring to the figures given here and the designations that are explained in the text, a proper size for the transformer-coil forms may be determined for any small experimental transformer.*

of turns into two coils each having the same number. All coils are of the "pancake" type because they are easily wound, insulated and assembled. In the example, the primary winding of 500 turns may be arranged in 25 layers with 20 turns per layer; the secondary winding of 24 turns may be arranged in 4 layers with 6 turns per layer.

When the coils have been arranged, then allowances for insulation between turns, between coils, between coils and the core, between coil ends and the core, and for the clearances in construction work, must be made.

Referring to Figure 3, the procedure is easily followed. Let N represent the number of turns per layer, n the number of layers, and d the diameter of the wire in inches over the insulation, which is found in the B.S. Gage Wire Table, then the width, w, of the coil is

$$w = N \times d \text{ inches} \qquad (5)$$

If t′ is the thickness in inches of the linen tape, and t″ the thickness of the fiber insulation, then the total width, W′, is

$$W' = w + 2t' + 2t'' \text{ inches} \qquad (6)$$

The value of t′ varies from 0.005 to 0.008 inch, and that of t″ from 1/32 to 1/16 inch.

Letting the letters represent the same as above and 0.125 inch for construction clearance, then the height, H′, of the coil in inches is

$$H' = n \times d + 2\,t' + 2\,t'' + 0.125 \qquad (7)$$

Applying the values of the preceding example to formulas (5), (6) and (7), there results

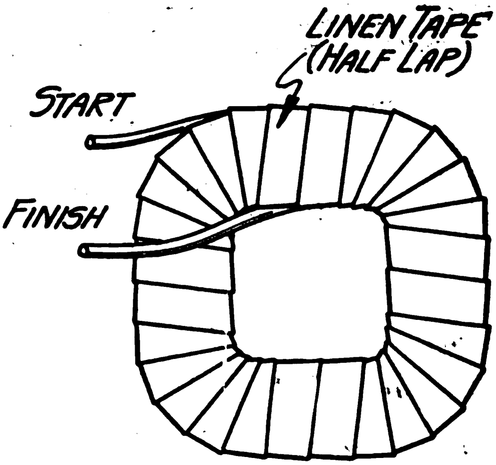
$$w = 20 \times 0.024 = 0.48 \text{ inch}$$
$$W' = 0.48 + 0.01 + 0.0625 = 0.5525 \text{ inch}$$
$$H' = 25 \times 0.024 + 0.01 + 0.03125 + 0.125 = 0.76625 \text{ inch}$$

Similarly the dimensions of the secondary coil are computed.

$$w = 6 \times 0.028 = 0.168 \text{ inch}$$
$$W'' = 0.168 + 0.01 + 0.0625 = 0.2405 \text{ inch}$$
$$H'' = 4 \times 0.028 + 0.01 + 0.03125 + 0.125 = 0.27825 \text{ inch}$$

Allowing 1/16 inch between coils and 1/8 inch on each end for clearance, then the length, L, of the core opening is the sum of the total widths of all the coils plus allowance between coils plus twice the clearance at each end, or

$$L = W' + W'' + 0.0625 + 2 \times 0.125 \text{ inches} \qquad (8)$$



WRAPPING THE COIL

FIGURE 5: *This diagram shows how the coil should be wrapped with tape when it is completed.*

The width, H, of the core opening is the largest value of the height of the coils obtained by formula (7) plus 1/8 inch for clearance, thus

$$H = H' + 0.125 \text{ inches} \qquad (9)$$

If a is the width of the core punching, then the length, R, of the long leg of the punching is the length L plus twice the core width, thus

$$R = L + 2 \times a \text{ inches} \qquad (10)$$

The length, S, of the short leg of the punching is the width H plus the core width, thus

$$S = H + a \text{ inches} \qquad (11)$$

The thickness of the core punching is 14 mils (0.014 inch) for frequencies from 50 to 100 cycles, and 20 to 40 mils (0.020 to 0.040 inch) for frequencies below 50 cycles. The number of core punchings required is determined by dividing the depth of the core by the thickness of the punching and multiplying the quotient by 2 since two punchings are required to form a closed core. The formula is

$$N_p = 2 \times a/t_p \qquad (12)$$

where a is the core depth which in a

square core is equal to the width, and t_p is the thickness of the punching in inches. An addition of a few punchings should be made to the value obtained by formula (12).

Substituting the values of the example in formulas (8), (9), (10), (11) and (12), there results

$L = 0.5525 + 0.2405 + 0.0625 + 0.25 = 1.1055$ inch

$H = 0.76625 + 0.125 = 0.89125$ inch

$R = 1.1055 + 2 \times 1.25 = 3.6055$ inch ($3\frac{5}{8}$ inches)

$S = 0.89125 + 1.25 = 2.14125$ inch ($2\ 9/64$ inches)

$N_p = 2 \times 1.25/0.014 = 179$—call it 200 punchings.

The width of the core in the above formulas is 1.25 inches.

The number of coils of a transformer depends upon its purpose. If it is to light the filaments of the tubes in the set, supply the "B" voltage, and also light the filaments of the rectifying tubes, then 3 or 4 coils are necessary. The output in this case is

$$P = P' + P'' + P''' \text{ volt amperes} \qquad (13)$$

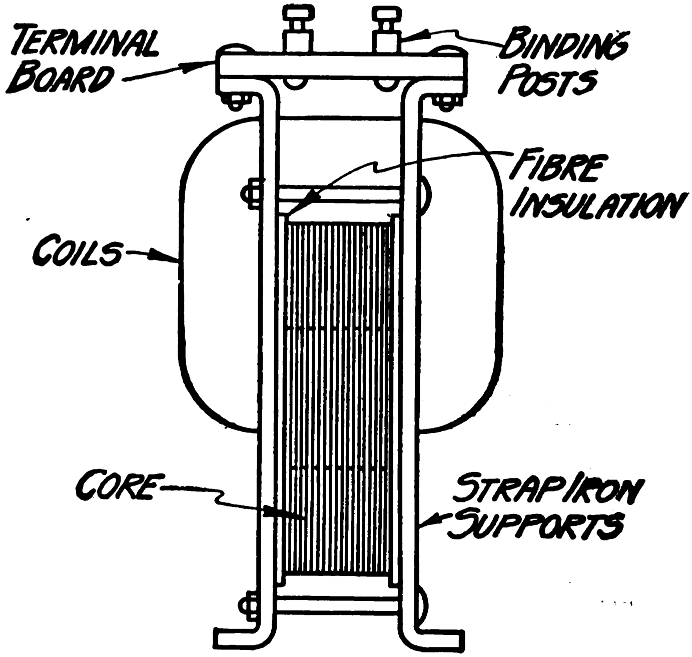
where P' is the output of the filament coil for the set, P'' is the output of the "B" voltage coil, and P''' is the output of the filament coil for the rectifier. The input is determined by substituting the value of (13) in formula (2) and dividing by the supply or primary voltage.

The number of turns of the various coils is determined from the different voltage ratios using the primary or supply voltage as a common voltage to all coils.

The size of wire is determined from the current to be carried in each coil as illustrated by formula (4). The primary current will be equal to the total output divided by the primary voltage.

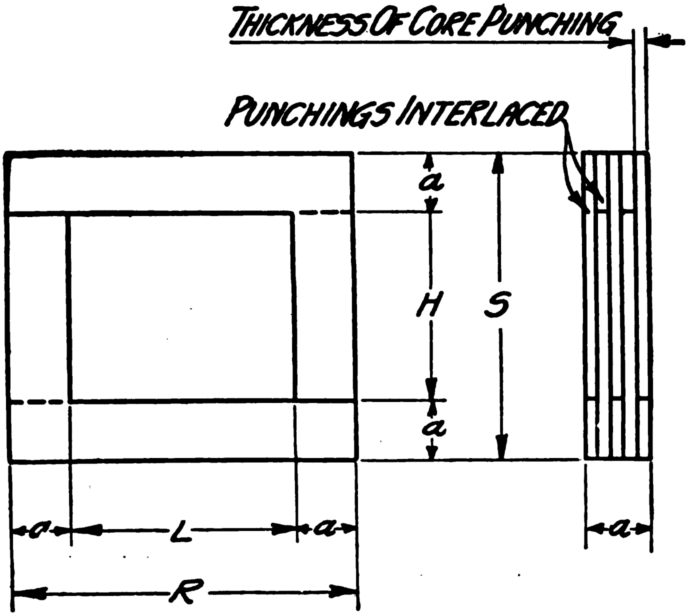
All the coils are placed on one leg of the core and the size of the punching is computed in a manner similar to that in the illustrative example.

This completes the necessary information for the construction of a transformer.



THE FINAL MOUNTING OF THE TRANSFORMER

FIGURE 6: *This drawing shows how the coils are assembled on the core with the strap iron supports in place and the terminal board and binding posts attached in the proper positions.*



THE DIMENSIONS FOR THE CORE LAMINATIONS

FIGURE 7: *How the core pieces of special iron are cut to size and assembled by interlacing with each other. The designations for the various dimensions are all explained in the article.*

Before the construction of the transformer is started, the necessary material should be secured. The number of punchings, which should be silicon steel, has been determined by formula (12). The quantity of wire of the required size can be calculated from the formula

$$\text{Pounds of wire} = \frac{0.2618 \times d \times N}{F} \qquad (14)$$

where d is the mean diameter of the coil in inches, N the total number of turns in the coil, and F the number of feet in one pound of wire (taken from the B.S. Gage Wire Tables). The amount of sheet fiber can be estimated by a rough calculation of the areas of coil ends, usually one square foot of 1/32 or 1/16 inch fiber will suffice. One roll of ¾ inch linen tape will be enough to wrap all the coils. About 3 feet of 3/16 inch by ⅝ inch strap iron will do for the clamps to hold the core punchings together. The miscellaneous material consisting of machine screws and nuts, binding posts, and a terminal board, is usually found in every experimenter's shop.

The coils are wound on a constructed wooden form which serves for all coils. The sides of the form may be of soft wood while the core should be of hard wood. Referring to Figure 4, the dimensions of the form are determined as follows: The width of the core is equal to the width of the core punching plus 1/8 inch (1/16 inch on each side) for clearance. The corners of this core should be rounded as shown in the figure (about 1/16 inch radius).

$$C = a + 0.125 \text{ inches} \qquad (15)$$

The two sides, one of which can be removed, thus permitting the wound coil to be taken from the form, are about ⅜ inch thick. The dimension, H_c, is equal to twice the largest value obtained by formula (7) plus the width of the wooden core plus ¾ inch allowance. Thus

$$H_c = 2H + C + 0.75 \text{ inches} \qquad (16)$$

The core and sides of the form are square. The width, W_c, is the largest width determined by formula (6). This width can be reduced to accommodate different coil widths by using the adjustable side (B), Figure 4, which has a square hole thereby permitting it to be slipped over the wooden core. When the side (B) is used, it is fixed to side (A). The form may be mounted in a lathe or some other suitable winding device. A revolution counter should be attached to the winding device thereby assuring accurate count of the number of turns.

Before winding, the fiber ends and fiber core are adjusted in place on the form. These may be held temporarily by pieces of cord or wire which can be removed when the first layer of wire has been wound. The coil is started by inserting the end of the wire (leaving enough for connections) through a hole in one side of the form. The initial reading of the counter is noted. The wire is fed under slight tension to the form which revolves at a speed convenient for the winder. The layers should be carefully wound so as to produce a neat compact coil. A coat of shellac may be applied after each second or third layer, and when the required number of turns have been completed, as indicated by the final figures of the counter, the coil is given a thorough coat of shellac and permitted to dry. The coil is then removed from the form and taped half-lap with linen tape, as shown in Figure 5. The finished coil is shellaced and then baked. The terminals of "start" and "finish" on the coil should be indicated. This is important if two coils are to be connected in series to increase the voltage; the direction of the turns in each coil must be the same.

The winding form is put together again with the fiber ends and core in place for the next coil. Each coil is taped, shellaced and baked. If it is desirable to wind a small coil, the side (B) is adapted as previously described.

The clamps that hold the core punchings together are made to serve as supports for the transformer and the terminal board. The clamps are made of strap iron and the dimensions are determined from the overall dimensions of the iron core and the top of the coils plus a clearance of about ½ inch for the terminal board, Figure 6. Ordinary machine screws and nuts may be used as bolts to tighten the clamps.

When the finished coils are arranged in an order such as shown in Figure 3, the punchings are fed from both sides through the opening in the coils. This leg is first built up and then the closing leg is sandwiched in. The core punchings are interlaced as shown in Figure 7. The completed core is squared up by tapping the punchings with a block of wood. The clamps, insulated from the iron core by fiber strips, are put in place and tightened up. The terminal board with binding posts is then mounted on the clamp supports, and the coil ends are connected to the binding posts.

This completes the transformer. The various coil voltages should be checked with an A.C. voltmeter before any connections to the set are made.

What Every Radio Experimenter Should Know About Condensers

IN POPULAR RADIO *for next month—December—will appear an article by Mr. Sylvan Harris that will give the reader some valuable but little known data about variable condensers, and particularly about the "low-loss" fallacies as applied to this type of instrument.*

Kadel & Herbert

TUNING AN ANTENNA INDUCTANCE

Here is a large transmitting inductance as used in the experimental radio-telephone transmitter at the College of the City of New York. In order to tune the transmitter to a certain wavelength, the man in the picture cuts in or out turns of the coil until the antenna ammeter before him indicates the maximum amount of current flowing in the antenna circuit.

Multi-layer Coils

Article No. 14

Useful data about coil construction that insure maximum inductance and minimum resistance and capacity

By SIR OLIVER LODGE, F.R.S., D.Sc., LL.D.

IN a previous article about interference that is caused by damping, I explained how the addition of inductance to a radio circuit prolongs oscillations and how the frequency of such a circuit can be controlled by inductance coils in which the phenomenon of damping occurs.*

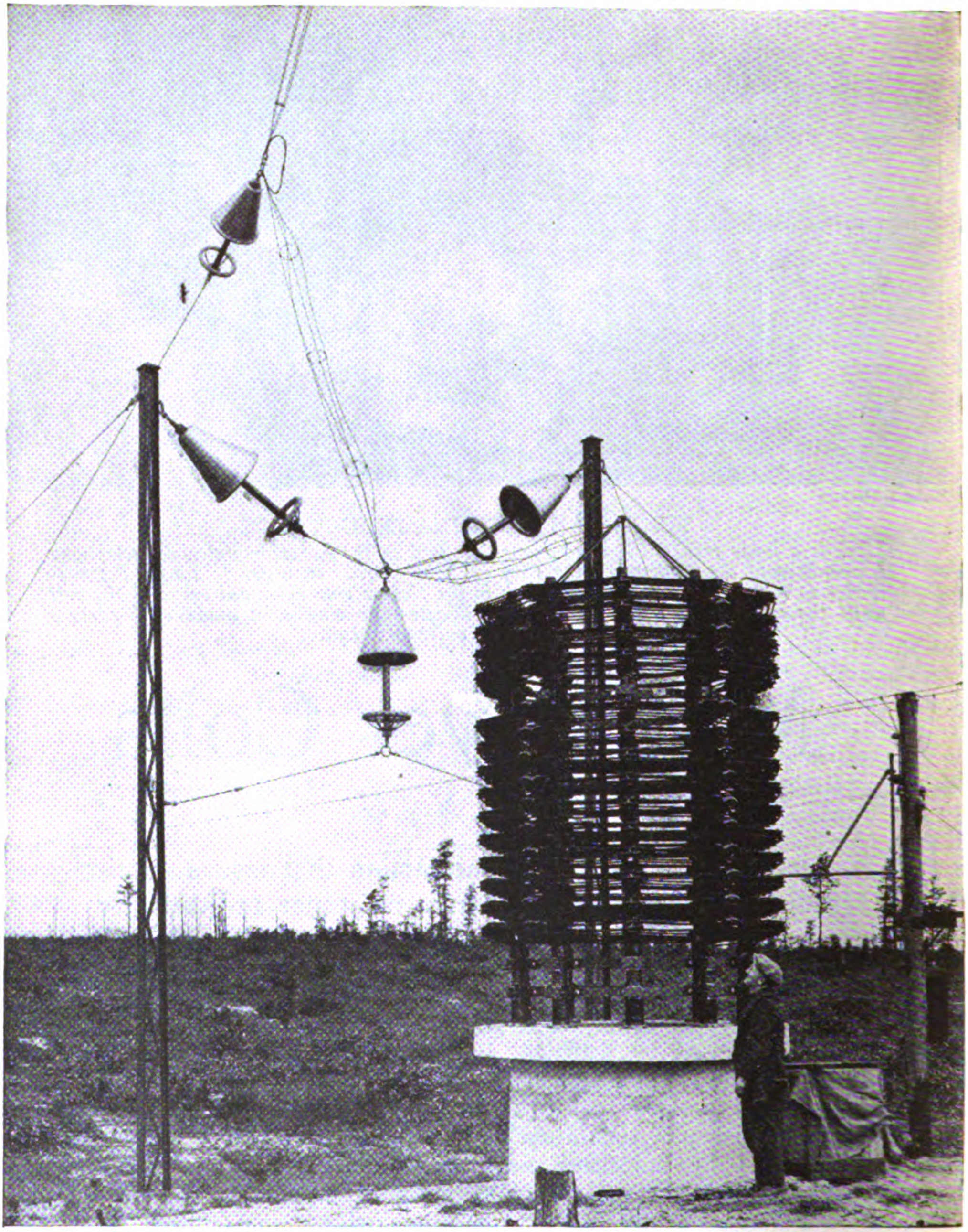
It is highly important that the capacity of these inductances be kept as low as possible. To overcome the effects of capacity, coils must be wound in a particular manner and upon materials, if so wound, which will not tend to increase capacity.

Furthermore, wire of the proper dimensions and of a requisite number of turns must be used to reduce capacity in inductive circuits that would otherwise fail to tune sharply in a radio receiver.

Additional calculations for the proper wire that should be used and the dimensions of coils and the number of layers required on windings will be explained here for those who are experimenting

---

* "Why Damping Causes Interference," by Sir Oliver Lodge. POPULAR RADIO, vol. VI, No. 5, pages 452-456 (November, 1924).



Radio Corp. of America

AN OUTDOOR TUNING INDUCTANCE OF A HIGH-POWERED TRANSATLANTIC RADIO STATION

This massive coil is an antenna inductance at the Rocky Point radio central, located near New York. This type of inductance must be heavily insulated, as shown, and must stand clear of any neighboring objects that might lower its efficiency by drawing current from it by induction.

with the construction of inductance coils.

For coils to have the maximum value of inductance the channel for the wire should be three units square, the external diameter of the coil should be 14 units, and the internal diameter eight units. The particular "units" can be adjusted to suit the desired conditions. For instance, each "unit" might be chosen as a couple of millimeters.

Suppose the covered wire is $\frac{1}{x}$th of such unit thick; then the number of turns in each layer of the above coil is 3 x, and there will be 3 x layers. So the number of turns is $9x^2$. The *mean* diameter of the coil is 11 units, and the average length of each turn is therefore 11π or say 34 units; wherefore the total length of wire will be $34 \times 9x^2$. The inductance of a coil of this shape has already been shown, by general reasoning and calculation, to be *3 n l*, being the maximum obtainable for that length of wire and therefore for that resistance and capacity. So we discover that the inductance comes out

$$L = 3nl = 8100x^4$$

of the same units of length approximately, taking 3×34 as 100. If the unit selected is, as above suggested, a couple of millimeters, and if the value of x is, say 10—both these things being arbitrary—the value of L, as thus calculated, is $1{\cdot}62 \times 10^7$ millimeters, or 16·2 kilometers, or 1·62 millihenries.

The maximum deleterious or distributed capacitance of such a coil would be obtained, as above, by reckoning $\frac{rb}{T}$, which is $5{\cdot}5 \times 3 \times x$ of the same unit; or, if the unit is a couple of millimeters and n = 10, as above, the capacitance is 330 millimeters, which is a third of a meter.* This is not too big, and is capable of reduction by basket-winding.

To reckon the resistance, we should have to know the thickness of the uncovered wire, and its conductivity; but resistance is a thing easily obtained by direct measurement, and is hardly worth pre-determination, as inductance is.

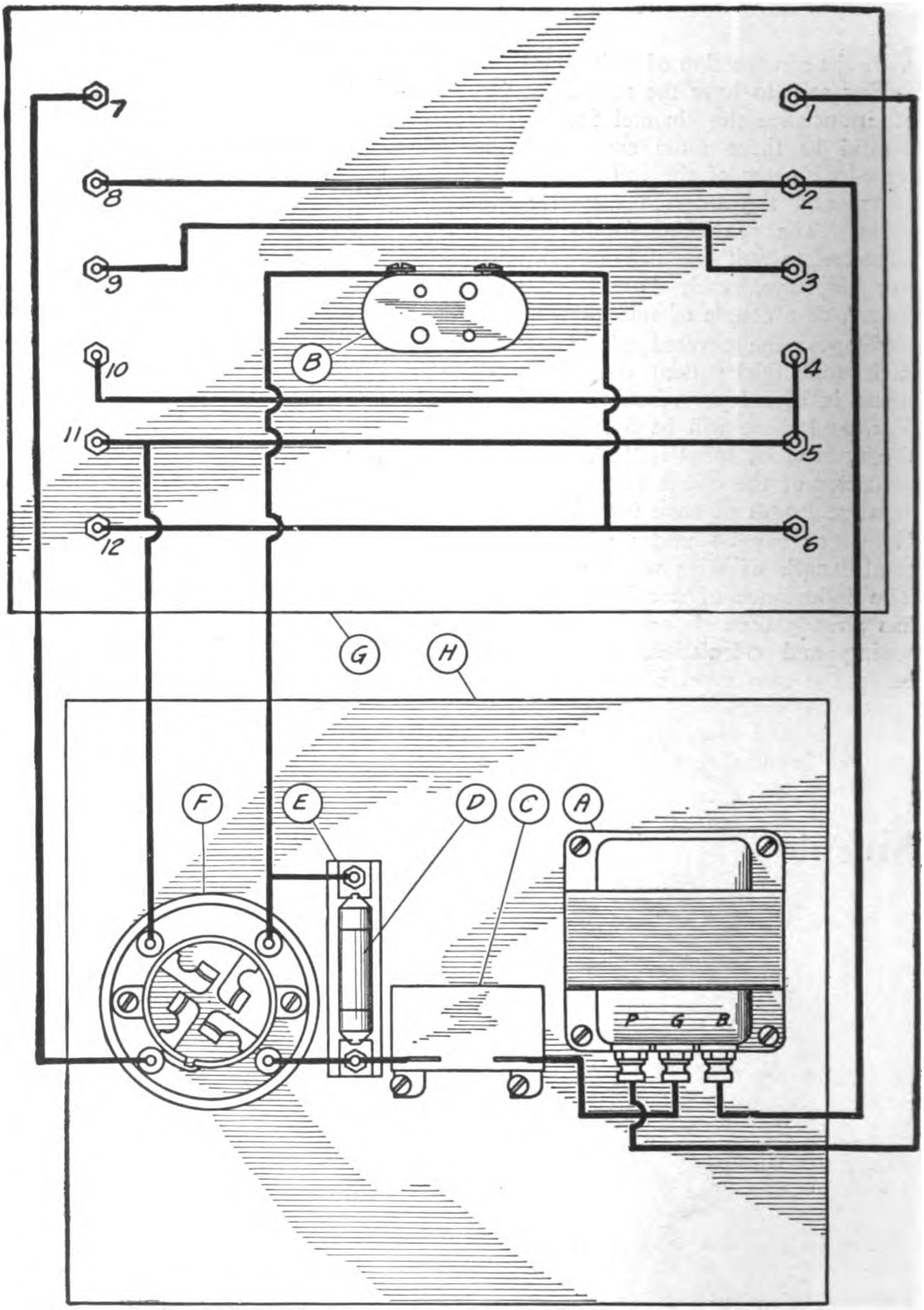
---

*This is approximately 37 micro-micro-farads. See appendix to Sir Oliver Lodge's article in POPULAR RADIO for September, 1923.

Kadel & Herbert

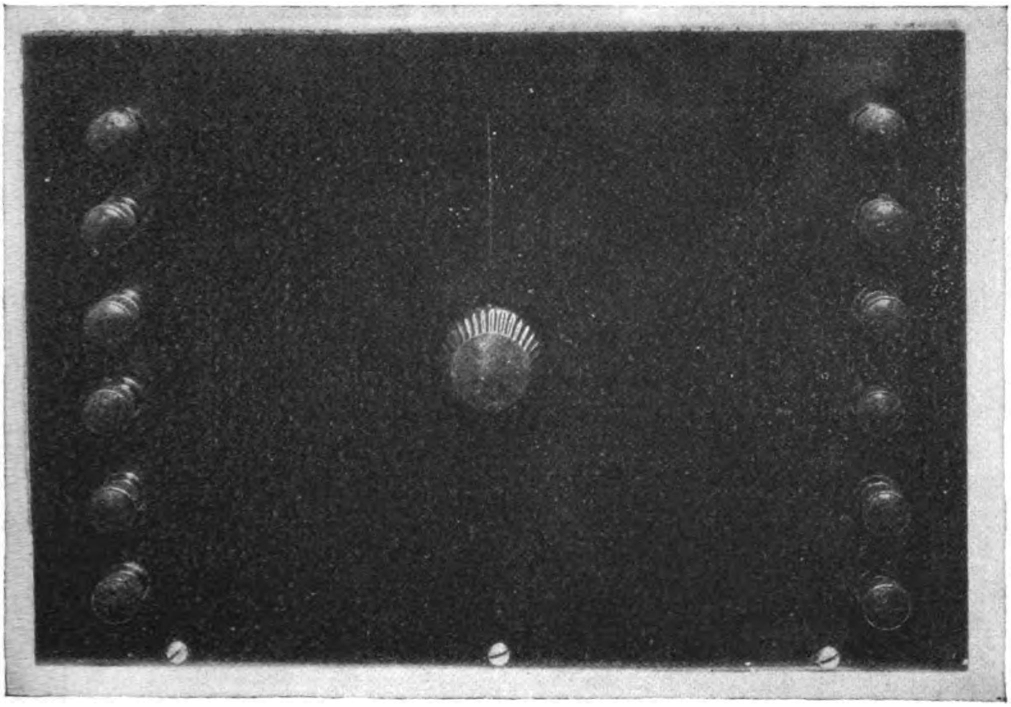
A NOVEL MARKING SYSTEM FOR A RECEIVER

The picture illustrates how Mr. George Jacobson indicates, by paper markers, the dial location of each station. He notches the piece of sheet copper (shown fitted into a slot that covers the face of the calibrated dial). His indicator is attached directly to the dials.



THE "PICTURE DIAGRAM" OF THE HOOK-UP

Figure 1: *This illustration shows the exact manner in which the instruments are placed on the panel and baseboard and how the wires run in relation to them. The upper rectangle shows the back of the panel, and the lower one shows the baseboard. All the parts are lettered to correspond with the designations in the text and in the list of parts.*



THE PANEL ARRANGEMENT

Figure 2: ***This picture shows the front view of the panel with the rheostat mounting in the center and the binding posts in two rows, one at each end.***

Simple "How-to-Build" Articles for Beginners
No. 13

How to build a single-stage impedance-coupled amplifier for use with a standard 6-volt tube

By LAURENCE M. COCKADAY

Cost of Parts: *Not more than $13.50*

Here Are the Items You Will Need—

A—Thordarson autoformer;
B—Bradleystat;
C—Deutschmann bypass condenser, 1 mfd.;
D—Bradley unit resistor, 500,000 ohms;
E—Electrad resistance mounting;
F—Naald standard vacuum-tube socket;
G—composition panel, 7 inches high by 10 inches long;
H—hardwood baseboard, 7 inches by 8¾ inches; twelve binding posts.

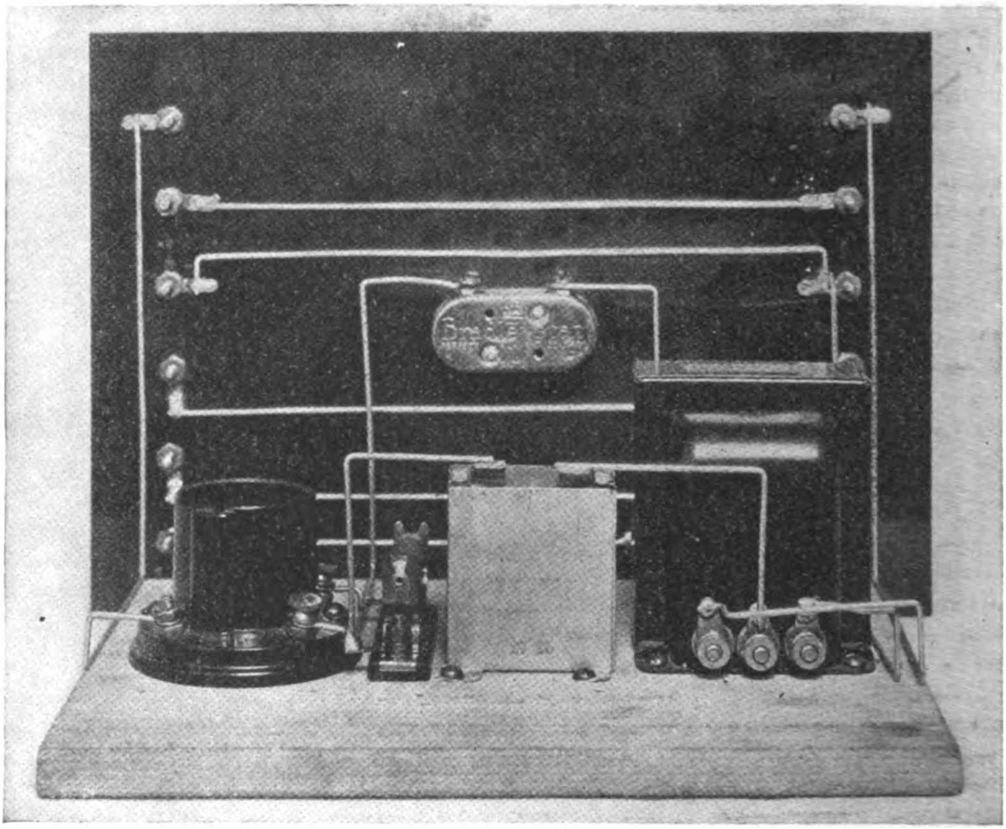
THIS thirteenth unit of this series is a single-stage vacuum-tube audio-frequency amplifier that utilizes the principle of impedance-coupling.

This unit will be found efficient and useful for connecting to the preceding detector or amplifier units that have been described in this series.*

This amplifier was built in the Popular Radio Laboratory for the express purpose of submitting to the amateur be-

---

*See Popular Radio for September, 1925.



THE REAR VIEW OF THE AMPLIFIER

FIGURE 3: *Study this view in connection with the picture diagram of the amplifier in Figure 1. The location and connecting points of each wire appear clearly and you can determine just how to bend the wires to get the shortest connection with the proper clearance.*

ginner an impedance-coupled amplifier that will give him fine reproduction, and at the same time teach him something of the theory that is involved in impedance audio-frequency circuits.

After a decision has been reached by the prospective builder, take these pages to a radio dealer and ask him to supply you with the parts listed at the head of the article. When you have your parts ready for mounting, you may spread them out on a kitchen work-table and begin the construction of the unit.

Mount them on the panel and baseboard as shown in the picture diagram and the two other illustrations that accompany this article. These three illustrations show you exactly how to mount the instruments and also exactly where to put the wires that connect them together in the electrical circuit.

Next, connect up the instruments in the electrical circuit as indicated specifically in the picture wiring diagram.

If you follow the directions shown there you cannot make a mistake, as the instruments are all marked with designating letters that reappear in the list of parts.

When you have finished wiring up, all you have to do is connect the telephones or loudspeaker, the batteries and the tuning unit, and you are ready to begin reception.

To connect this unit, be sure to do the following:

Place the tuning unit on the table and connect the antenna and ground:

Then, connect this amplifier alongside of it on the right-hand side by bridging across the binding posts 1, 2, 3, 4, 5 and 6 to those on the tuning unit. Binding posts 1 and 2 are the input terminals to the impedance. Binding posts 3 and 4 are the "B" battery connections, and binding posts 5 and 6 are the "A" battery terminals. Binding posts 3 and 5 are the positive terminals in each case.

Then connect the "A" battery across the terminals 11 and 12 with the positive terminal on binding post 11. Connect the "B" battery across binding posts 9 and 10 with the positive terminal on post 9. Connect the telephones or loudspeaker across posts 7 and 8.

If the tuning unit uses a "soft" detector the connection on this unit between 3 and 9 should be disconnected and the 22½-volt "B" battery tap applied to post 3. The amplifier voltage of 90 volts may then be applied across 9 and 10 as previously stated:

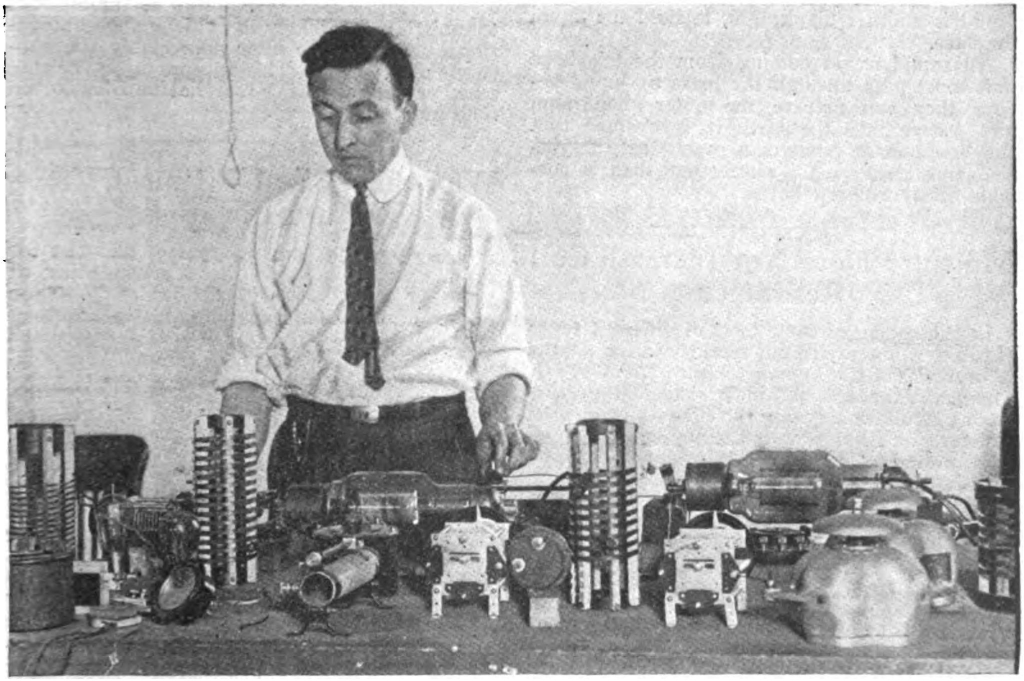
If this amplifier is to be used following another amplifier, however, it should be left as shown in the diagram without any change in the wiring.

Place a UV-201-a tube in the socket, F, and turn up the rheostat, B, and the unit is ready for operation.

You will find that you will obtain truthful reproduction if a good loudspeaker is used with this type of amplifier.

Do not turn up the rheostat which controls the filament current to the tube any higher than is necessary to produce sufficient volume. This will conserve the batteries and lengthen the useful life of the tube.

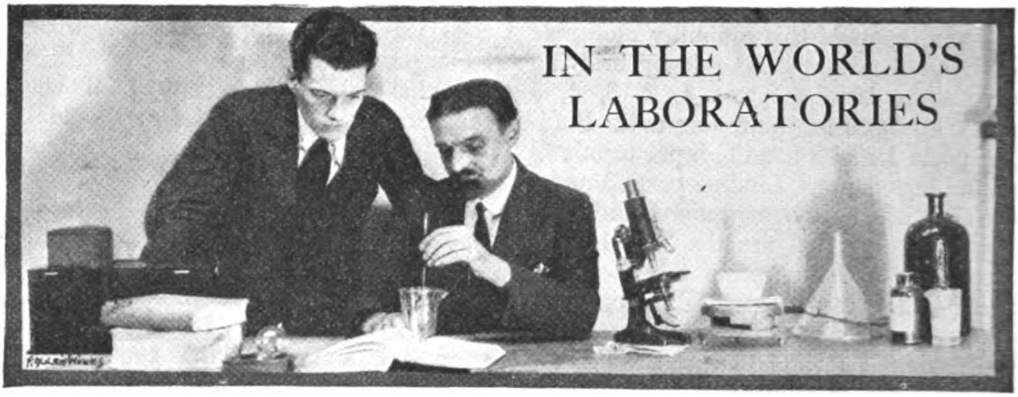
There are no further adjustments to be made in the operation of this simple amplifying unit.



Henry Miller

A 17-METER TRANSMITTER

This experimental apparatus has been developed at the United States Naval Research Laboratory; it has been used in daylight communication with the MacMillan Arctic Expedition. Mr. R. S. Fisher, Associate Engineer of the Laboratory, is here shown making an adjustment on the transmitter at the U. S. Naval Research Laboratory at Bellevue, D. C.



IN THE WORLD'S LABORATORIES

CONDUCTED BY DR. E. E. FREE

A Liquid-filled Loudspeaker

A NOVEL idea in loudspeaker design comes from an amateur in France. He fills the inner part of the horn, where its diameter grows small toward the telephone attachment, with a liquid; for example, with water.* The small end of the horn is closed by a diaphragm which is connected to the moving part of the telephone unit. Through this diaphragm the sound waves enter the liquid. In front of the liquid is another diaphragm, to hold the liquid in place.

All sound waves coming from the telephone unit must pass through the mass of liquid before they can actuate the outer diaphragm and escape into the air. It is claimed that the liquid mass removes a great deal of "rattle," thus delivering a purer tone than is possible with ordinary horns.

Moisture Does Not Increase Coil Resistance

IN the course of some tests of different types of tuning coils carried out recently in the testing laboratories of the *Popular Science Monthly*, Mr. Thomas Vanacore obtained some rather surprising results concerning the effect of condensed moisture on the radio-frequency resistance of coils wound of number 22 insulated wire on three-inch composition tubing.† The coils were 44 turns each. One was wound with double-silk-covered wire, one with double-cotton-covered wire and one with enameled wire.

All three coils were first tested dry. They were then put for three hours in a closed box containing boiling water. Presumably the windings absorbed a considerable amount of moisture. A re-test showed no appreciable increases of resistance, even for frequencies as high as 1,500 kilocycles (200 meters). The coil wound with cotton-covered wire was then dipped in water and tested again. So long as liquid water was present between the windings of the coil the resistance was nearly seven times higher than before, but so soon as the coil had dried a little its resistance returned to normal.

While these results require confirmation and extension—especially by the actual determination of the amount of moisture present in the windings at the moment of test—they establish a probability that the exposure of tuning coils to moist air is unlikely to cause enough absorption of moisture to alter appreciably the constants of the coils. This appears to be the case whether the insulating material be silk, cotton or enamel.

Why the Coated Filament Emits More Electrons

ONE of the prominent types of filament for radio vacuum tubes is the one consisting of tungsten wire coated with the oxides of barium or strontium. This coating greatly improves the electron emission and it was these coated filaments which first made possible the low-temperature filament used in the 199-type tubes and other dry-battery tubes.

A detailed study of the behavior of these coated filaments under various conditions has been made by Mr. Lewis R. Koller of the Edison Lamp Works of the General Electric Company.* He finds, among other things, that a very slight trace of oxygen in the tube decreases the electron emission enormously. Certain other gases cause increases. This means, Mr. Koller believes, that the unusually high emission of these coated filaments is not due to a film of the oxide, but to an actual film of metal—of metallic barium or stontium—into which the oxide originally added has become converted.

---

*A note by M. Louis L'Hopitault in *Radio-Électricité* (Paris) vol. 6, page 176 (May 10, 1925).

† "Surprising Facts About Tuning Coils," by Thomas Vanacore. *Popular Science Monthly* (New York), vol. 107, number 2, pages 70 and 117 (August, 1925).

*"Electron Emission from Oxide Coated Filaments," by Lewis R. Koller, *Physical Review* (Corning, N. Y.), vol. 25, pages 671-676 (May, 1925).

This is believed to be true, also, of the thoriated filament, which is a filament the wire of which contains a trace of the metal thorium. This thorium comes to the surface of the filament. The layer of thorium atoms acts to increase the emission. Just why a layer of atoms of metallic thorium or barium or any other metal should behave in this way is still one of the mysteries of physical science. Doubtless it is related to the atomic structures of these metals.

Driving Sodium Atoms Through Glass

The use of photoelectric cells for the conversion of light energy or of light-ray signals into electric energy or electric signals is growing in many fields of scientific and industrial work, including radio. Most of these photoelectric cells depend either on the element selenium or on one of the alkali metals, sodium, potassium, rubidium, caesium and lithium. Much interest attaches, therefore, to a process, recently perfected by Dr. Robert C. Burt, of the California Institute of Technology, by which sodium atoms can be driven through the glass walls of an ordinary electric lamp bulb, producing a coating of very pure metallic sodium on the inside walls of the bulb.*

The bulb is placed, tip down, in a bath of melted sodium nitrate, kept at a temperature of approximately 312 degrees, Centigrade (583 degrees, Fahrenheit). A current is passed through the filament of the bulb in the usual manner. An electrode dips into the melted sodium nitrate and a voltage of approximately 220 volts is maintained between this electrode and the mid-point of the filament in the bulb, the filament being negative. Under these conditions, when electrons escape from the heated filament (just as they do from the filament of a radio vacuum tube) they are drawn against the inside surface of the glass by the potential difference between the filament and the outside bath of fused sodium nitrate. It is as though the glass were the plate of a vacuum tube.

The glass of the bulb contains sodium and the atoms of this sodium (or some of them) are able to move around in the glass. When the electrons from the filament hit against these mobile sodium atoms they neutralize them and the atoms then come out on the surface of the glass and form a layer of metallic sodium. What happens, in the language of the physical chemist, is that sodium *ions* in the glass acquire one electron each and become free sodium *atoms*. Meanwhile, new sodium ions enter the outside surface of the glass, coming from the bath of sodium nitrate. The overall effect is, therefore, the driving of sodium atoms through the glass, to produce a metallic layer on the inside.

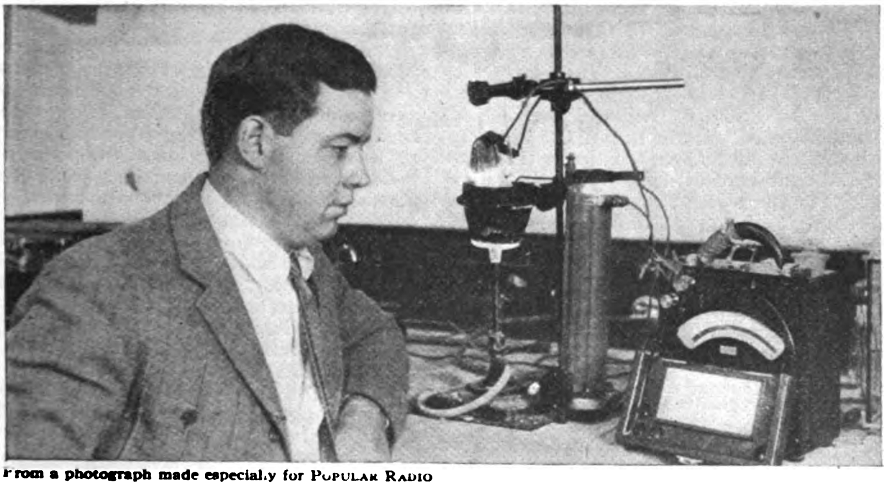
While this process is not at all difficult to carry out in any well-equipped radio laboratory there are some conditions and precautions which cannot be described in a brief note. Experimenters intending to make use of Dr. Burt's process should first consult his paper referred to, where they will find all necessary details.

Alexanderson's Theory of Twisting Waves

That a twisting of radio waves as they pass over the earth's surface may explain some of the mysteries of fading—and may be put to practical use in other directions—is the theory proposed

---

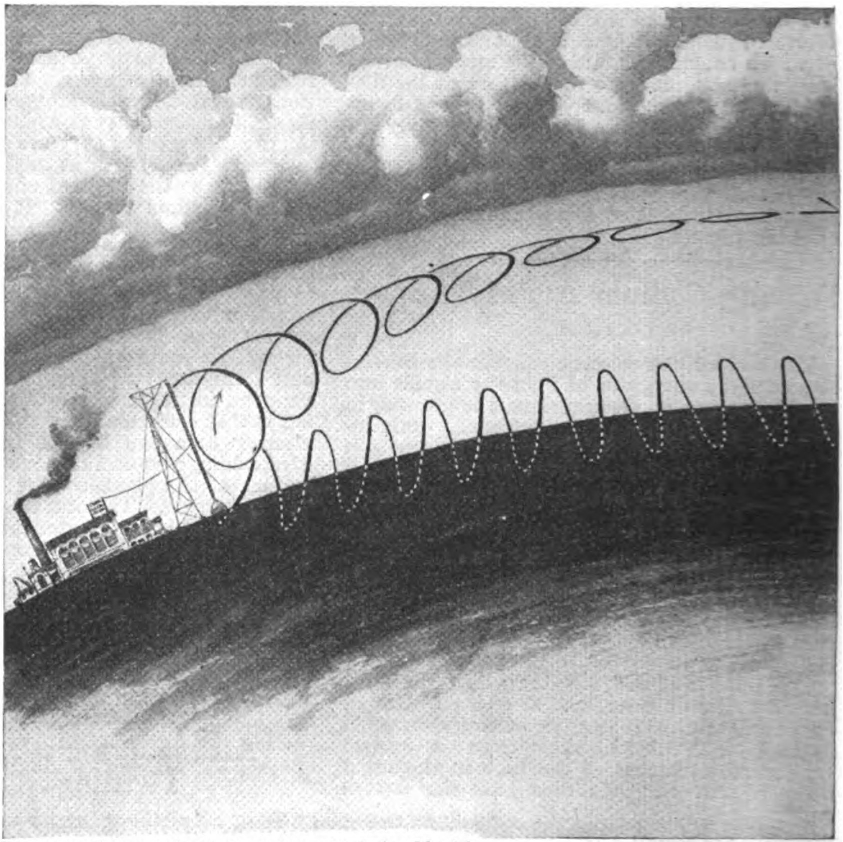
* "Sodium by Electrolysis Through Glass," by Robert C. Burt. *The Journal of the Optical Society of America* (Menasha, Wisconsin), vol. 11, pages 87–91 (July, 1925). We are indebted to Dr. Burt for some additional information.



From a photograph made especially for Popular Radio

HOW SODIUM ATOMS ENTER A LAMP BULB

The lamp bulb, inverted in a bath of molten sodium nitrate, is visible in the center, just in front of Dr. Burt. The base of the bulb is removed and a glass tube is sealed to its side, so that a wire can enter to make contact with the sodium coating which will be formed inside the glass.



From a drawing made for POPULAR RADIO by Arthur Merrick

HOW THE EARTH'S MAGNETISM CAN TWIST A POLARIZED RAD-

Some antennas produce a polarized radio wave—which means a wave that vibrates only in of polarization is slowly twisted. The upper wave in the drawing starts with a vertical (at the center of the page) the gradual twist has made the wave horizontally polarized; it receiving station the wave is again vertically polarized, but it is now upside down. polarization. The two waves will now inter-

recently by Mr. E. F. W. Alexanderson, Chief Consulting Engineer of the Radio Corporation of America, a theory now undergoing active discussion and examination in many of the radio laboratories of the world.*

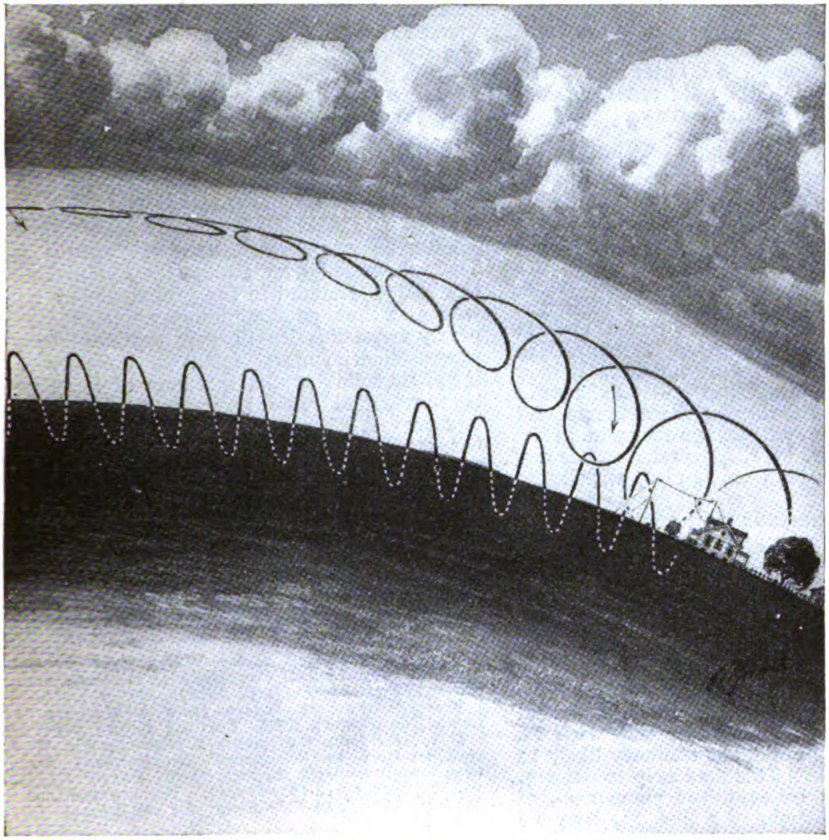
The essential of this theory is the idea of polarized waves, an idea already quite familiar to students of the shorter electromagnetic waves which we call light. You must form a clear mental picture of what polarization is before the Alexanderson theory of twisting waves will mean much to you.

Any ether wave may be thought of, you remember, as a vibration of the ether in a direction at right angles to the motion of the wave. A cork bobbing up and down on the surface of a pond of water, as water waves pass under it, is an exact model of what we believe happens in the ether. We are not sure that the ether has any "particles" in it, but it is convenient to think of it as though it had and to imagine these little ether-particles as moving up and down when an ether wave passes them. The upward swing of the particle is one phase of the wave; the following downward swing is the other phase.

But in ordinary ether waves not all of these swings of the ether particles are up-and-down. Some of them are right-and-left, some are at angles of forty-five degrees to the vertical, and so on. It is as though a lot of corks on water were set bobbing in all conceivable directions as a wave passed them, not merely up and down. This is difficult to imagine for water, but it is easy enough to see how there could be two such directions of motion for the bobbing cork; one of them up and down (as usual), the other hori-

---

* Mr. Alexanderson announced the theory in newspaper statements released beginning July 19, 1925. An account, under Mr. Alexanderson's signature, was published in the Radio Magazine of the *New York Herald-Tribune* on July 26, 1925, page 3, and in the radio section of the *New York Telegram* on August 1, 1925, page 2, as well as in other newspapers throughout the United States. Later statements, based on subsequent interviews with Mr. Alexanderson, appeared as follows: by H. G. Silbersdorff in the radio section of the *New York Sun*, August 8, 1925, page 3, and in the radio magazine page of the *New York Evening World*, August 22, 1925; by R. K. Squire in the *New York World* (morning), August 16, 1925; by Everett M. Walker in the Radio Magazine of the *New York Herald-Tribune*, August 23, 1925, page 2.



IO WAVE SO THAT INTERFERENCE AND FADING ARE PRODUCED
one direction. As such a wave passes through the earth's magnetic field the wave's plane polarization; its vibrations are up and down. When half the path has been completed vibrates back and forth parallel to the surface of the earth. The twist continues. At the Accordingly it is reverse to the ground wave, which has retained its original up-and-down fere and will produce fading or a "dead spot."

zontal, along the water surface. If the surface of the water were swung back and forth, from left to right, as it would be by rotating a pail or tub that held it, this would give the horizontal back and forth motion of the cork.

In the ether we can have these vertical and horizontal waves too. Ordinarily we have both of them and many other waves vibrating at different angles between horizontal and vertical. A beam of light contains, for example, some ether waves which are vibrating vertically, others which are vibrating horizontally, still others vibrating at every angle in between. So far as the direction of vibration is concerned, all ordinary light beams are composed of mixed waves.

It is possible, however, to sort out these mixed beams and to produce light in which all the vibrations are up-and-down, or all of them horizontal, or all of them in any other selected direction. This is called *polarized* light. It means merely that all the waves are vibrating in the same plane. A wave on a pond of water is a naturally polarized wave; its vibration is exclusively up and down. The ordinary wavy line which we draw in diagrams to depict an ether wave is really a polarized wave. If we wanted to depict an unpolarized wave we would have to draw an infinite number of such wavy lines, all at different angles to the surface of the paper, thus showing that the vibration is really a mixed one, occurring in many directions at the same time.

Radio waves are subject to exactly these same conditions of polarization. Long ago, during the early experiments of Hertz, the possibility of generating a polarized radio wave was discovered. Such waves were produced and their properties were studied. These facts, however, have dropped out of use and out of the minds of radio men. Mr. Alexanderson has brought them back.

The degree of polarization of a radio wave depends, primarily, on the nature of the antenna which generates the wave. Some antenna systems produce mixed waves, vibrating in nearly all directions, like a beam of ordinary light. Other antennas produce horizontal waves, analogous to the motion of a water surface caused by rotating the pail back and forth. An antenna consisting of a horizontal loop of wire will produce such horizontally-polarized waves. The ordinary vertical antennas produce, in the main, waves which are vertically polarized, analogous to an ordinary up-and-down water wave. By using straight vertical rods for antennas, this vertical polarization of the wave can be made nearly perfect.

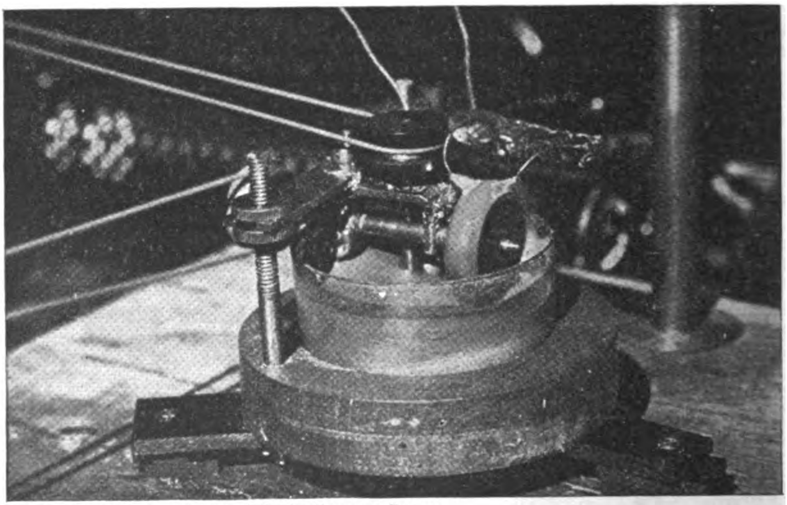
The next step is the possibility of altering the direction of polarization of the wave as the wave moves. Suppose, for example, that you generate a wave in which the vibrations are altogether up-and-down and that this wave starts out on its journey through space. The up-and-down character of the vibrations may change. A magnetic field, for example, will *rotate* the direction of polarization of the wave, so that the wave twists. Presently the direction of polarization will be horizontal, instead of vertical. It may even twist around altogether, so that the wave is exactly upside down. All these twists and rotations have been well known for years in the case of light waves. Mr. Alexanderson has discovered that they can exist, also, with radio waves.

If a radio wave starts out with an up-and-down polarization, as, for example, from a vertical-wire antenna, it is likely to maintain that position so long as the wave follows the ground. The partially-conducting ground or ocean acts as an anchor, so to speak, for the wave. It keeps the direction of vibration upright. But if the wave starts out horizontally it has no such anchor. It will usually twist around as it moves. Also, the vertically-polarized waves which travel high up in the atmosphere, so that they lack an anchorage to the ground, are similarly likely to twist as they move. This may help to explain, Mr. Alexanderson believes, the phenomena of fading, dead spots, and the like. It may be possible, also, to make use of purposely polarized waves to attain long-distance transmission or for other purposes. The practical applications of these phenomena of wave polarization in radio may prove to be quite important. They remain to be worked out.

A New Generator for Ultra-short Radio Waves

THE famous experiments of Nichols and Tear, described over two years ago in POPULAR RADIO, resulted in the production of radio waves as short as .22 millimeter.* Heat waves nearly twice this length were produced by the same experimenters from a mercury arc lamp, thus linking the spectrum of light rays, heat rays and radio waves into a continuous whole.† A Russian physicist, Madam A. Glagolewa-Arkadiewa, has now succeeded in producing radio waves even shorter than those of Nichols and Tear. Her shortest are only .082 millimeter long. More important still, she has devised a new and promising method for the production of ultra-short radio waves of any wavelength.§

The new generator consists of iron filings. These are suspended in oil, which is kept



From a photograph made especially for POPULAR RADIO

THE IRON-FILING OSCILLATOR FOR SHORT WAVES

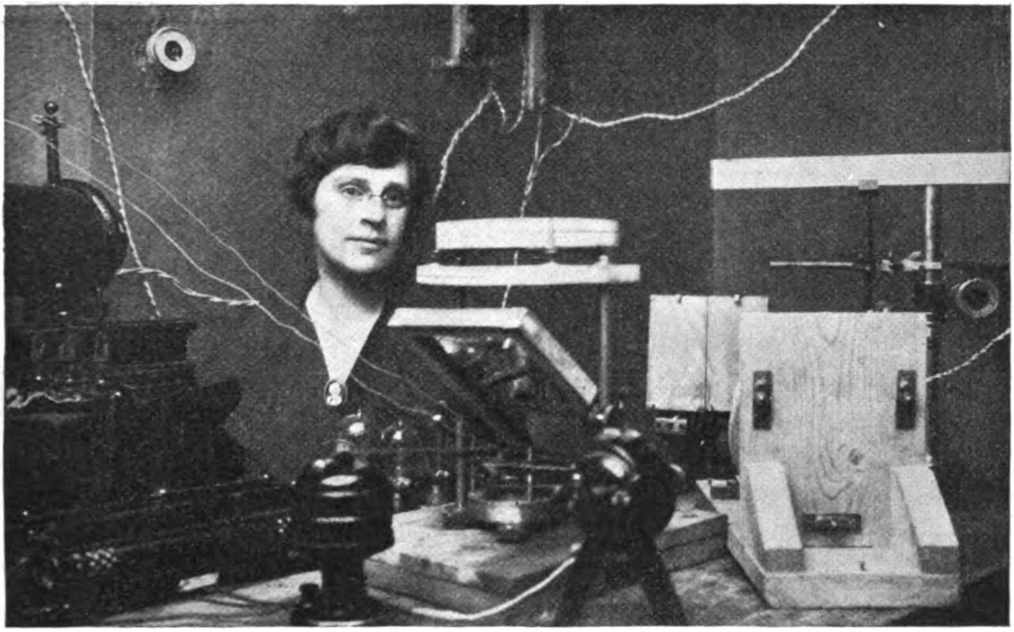
With this apparatus, Madam Glagolewa-Arkadiewa has been able to produce relatively intense beams of ultra-short radio waves, shorter than one ten-thousandth of a meter. The dish contains a mixture of iron filings and oil. This mixture is lifted on the rim of the small wheel and the discharge of an induction coil passes between the two terminals visible just above the wheel.

---

*See "The Shortest Radio Waves Ever Produced by Man," by Ernest Fox Nichols, POPULAR RADIO, vol. 4, pages 22-29 (July, 1923).

†See "Ultra-short Waves from a Mercury Arc Lamp," in August, 1925, POPULAR RADIO, page 175.

§"A New Source of Short Electromagnetic Waves of Ultra-Hertzian Frequency" (in German), by A. Glagolewa-Arkadiewa, *Zeitschrift für Physik* (Berlin), vol. 24, pages 153-165 (1924). We are indebted to Madam Glagolewa-Arkadiewa for additional information.



From a photograph made especially for POPULAR RADIO

STUDYING THE ULTRA-SHORT WAVES

The waves from the generator pass upward, through a hole in the inclined mirror, against the horizontal, disc-shaped mirror. On downward reflection from this, the waves are directed to the right by the inclined mirror. The two-plate mirror on the right is a part of the interferometer by which the waves are measured. Madam Glagolewa-Arkadiewa stands behind the apparatus.

stirred mechanically so that the filings will not settle. Into the mixture of oil and iron filings there dips a slowly rotating wheel, so that a layer of the oil-filings mixture is carried up on the edge of the wheel, like mud on a wagon tire. The two leads from an induction coil dip into this rim of filings on the wheel. The discharge occurs through the oil-filings mass, so that each tiny bit of iron becomes a miniature broadcasting station. The wavelength of the waves sent out depends, in the main, on the size of the bits of iron in the filings. These are the oscillators.

Madam Glagolewa-Arkadiewa measured the waves thus produced, using a thermocouple and an interferometer similar in principle to the instrument used by Nichols and Tear. She found it possible to get waves of almost any wavelength in the range of ultra-short waves, down to the limit already mentioned of .082 millimeter. The radiation is never "sharply tuned," so that all of it would be of the same wavelength. The wavelengths depend on the size of the particles of iron and these are never of exactly the same size. However, the method is said to produce a much more intense radiation than that of Nichols and Tear, which is understandable when one thinks of the many individual bits of iron that are radiating simultaneously.

Further work is being carried out with the method, which is believed to be susceptible of considerable improvement; for example, by using small, uniform iron spheres instead of the angular filings. This ought to concentrate the radiation much more completely at a single wavelength. Another possibility which may be suggested is the use of a larger volume of the mixture of filings and oil, perhaps excited inductively by a nearby spark-gap connected to high-capacity condensers. It is to be hoped that experimenters everywhere will try out the new method and some of the extensions of it which seem possible.

New Resonance Indicator for Wavemeters

MOST varieties of wavemeters depend on adjusting a local tuned circuit to resonance with the wave to be measured. The point of exact adjustment is marked by some form of resonance indicator. Usually this is some type of radio-frequency thermo-galvanometer.

The United States Bureau of Standards has recently improved on this method by substituting for the thermo-galvanometer a combination of a crystal detector and a sensitive milliammeter.*

---

* "An Improved Type of Wave Meter Resonance Indicator," by Morris S. Strock. United States Bureau of Standards, Scientific Paper Number 502 (vol. 20, pages 111-118), issued March 6, 1925. Obtainable from the Superintendent of Documents, Washington, D. C., for five cents, postpaid.

The hook-up provides a combination of capacitive and inductive coupling. The new indicator is said to be more sensitive than the thermogalvanometer and more uniform in its response at different parts of the wavelength scale. It can be attached to most of the types of resonance wavemeter now in use.

New Facts About Wave Propagation

CAPTAIN T. L. ECKERSLEY, the well-known research engineer of the Marconi Company and of the British Broadcasting Company, has made two recent contributions of considerable importance to the newer theories of radio wave movement through the atmosphere and around the earth.* In the first of these contributions he studies the peculiar musical noises often heard if a telephone is placed in series with a large antenna.† These noises usually start, Captain Eckersley reports, with a sharp click and a tone which is too high in frequency to be audible. The frequency rapidly decreases, so that a musical tone is heard. The pitch of this tone then falls rapidly to a constant value of the order of 300 to 1,000 cycles, at which pitch the tone dies away.

From calculations which are too mathematical for short summary Captain Eckersley concludes that these musical sounds must be due to an electric disturbance originating high up in the atmosphere, probably from some electric impulse from outside the earth. This disturbance gradually dies away. The limiting lowest pitch of the tone heard in the receiver enables the calculation of some of the electrical characteristic of the layer of air in which these disturbances originate and die. These characteristics turn out to be much the same as those assumed, on other grounds, for the ionized layer of upper air contemplated by the recent wave-propagation theories.

The other recent contribution of Captain Eckersley is a calculation of the probable behavior of waves of different wavelength, propagated around the earth according to the recent theories of air ionization and wave motion.* On the usual assumptions as to the number of air ions and the like, Captain Eckersley finds that the waves longer than about 400 meters and the waves shorter than about 40 meters should suffer relatively little from absorption by the ionized air. Between these limits, in the region of 400-meter to 40-meter waves, the atmospheric absorption should be very high, a result which is striking agreement with modern experience in the daytime transmission of waves of long, short and intermediate wavelengths.

A Crystal Control for Broadcasting Stations

THE application of the properties of quartz crystals to the construction of precision wavemeters is already familiar to the majority of radio enthusiasts.† Another step has now been

---

* For an account of these recent theories of wave propagation see "How the Air Affects Radio" in POPULAR RADIO for September, 1925, pages 199-206; also the article by Nichols and Schelleng on pages 309-316 of the October issue.

† "A Note on Musical Atmospheric Disturbances," by T. L. Eckersley. *The Philosophical Magazine*, vol. 49, page 1250 (June, 1925).

* The calculations have not yet been published in detail. Captain Eckersley summarizes his results in a letter to *Nature* (London), vol. 115, pages 942-943 (June 20, 1925).

† See "The Quartz Crystal as a New Wavelength Standard," by Dr. Walter G. Cady, in POPULAR RADIO for April, 1925, pages 357-365; also the photograph of a quartz-crystal wavemeter reproduced and described in this Department in POPULAR RADIO for June, 1925, page 569.

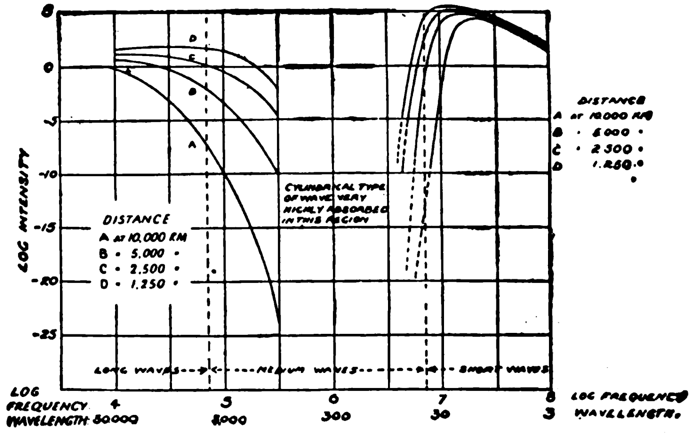


FIG. 1.

From *Nature*

ATMOSPHERIC ABSORPTION FOR DIFFERENT WAVELENGTHS

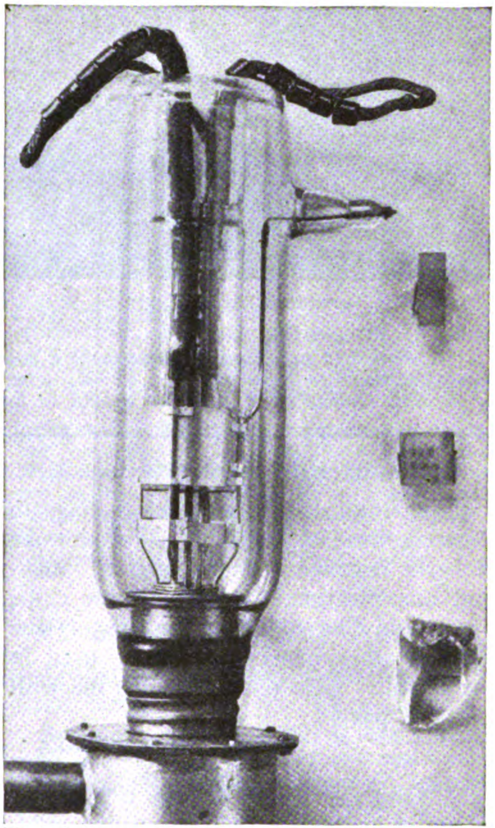
These curves, plotted from the calculations of Captain Eckersley, show how the absorption of the wave energy by the air is greatest for wavelengths close to the present broadcasting range. These curves are calculated, not observed, but agree fairly well with observed facts.

taken in the use of these remarkable crystals. They have been applied to the practical problem of maintaining the frequency of a broadcasting transmitter unchanged, so that the station may be accurately on the wavelength specified for it by the radio authorities of the United States Government. The new control method has been worked out by the engineers of KDKA, where it is now in use. It is to be extended, the Westinghouse Company reports, to WBZ, KYW and KFKX.*

It is a property of crystals of quartz, as well as of some other substances, that they contract or expand in size under the influence of electric forces. Conversely, an expansion or contraction of the crystal produces electric changes.

The use of such crystals for wavemeters depends upon the mechanical vibration of the crystal. Each crystal has, of course, a natural frequency at which it vibrates when hit or compressed, just as has a bell or one of the wooden strips of a xylophone. If a quartz crystal be placed in an oscillating circuit tuned to the natural frequency of the crystal, the mechanical vibration of the crystal will feed electric pulses of this same frequency back into the circuit. These can be made to reinforce and stabilize the oscillations of the circuit itself. If the circuit tends to vary in frequency the crystal will pull it back to its proper frequency.

This suggests a possible use of similar devices in reception. Many listeners desire sets which are tuned, automatically, to a certain limited number of stations. It is convenient, for example, to have four or five switches, one for each of the chief local stations. Anyone can then tune in a desired station merely by setting the tuning switch on the proper button. Such tuning arrangements are possible and are occasionally used but there is a disadvantage in that the same setting of condensers and coils does not always tune the set to exactly the same wavelength. Perhaps this can be accomplished with quartz crystals. It may be possible to get a set of these, each tuned to the frequency of one local station, and connect all of them in a receiving circuit so that each one, when thrown in by the switch, will hold the receiver rigidly on the desired wavelength. Here is an interesting problem for experimenters.



Westinghouse

REGULATING CRYSTALS

The one-kilowatt transmitting tube is contrasted with two plates of cut quartz, such as are used to regulate its frequency. The third crystal (below) is a fragment of natural quartz.

The Size of Light Particles

One form of the modern quantum theory holds that light is really composed of tiny particles, shot out from a luminous body like bullets from a gun.* It is usually assumed that these particles or "quanta" must be extremely tiny, only a few millionths of the size of an electron or even less. A contrary opinion has now been expressed, however, by Professor Gilbert N. Lewis, one of the foremost American chemists.†

In an article dealing chiefly with theories of chemical reaction, Professor Lewis and his collaborator find it necessary to calculate the "radius" of a quantum, meaning by that the nearest distance which the flying quantum can usually approach to an atom of matter without being absorbed by the atom.

The value comes out as approximately 1.4 x 10^{-7} centimeter, which is not only much larger than an electron, but is actually larger than an atom. Calculations made long ago by Lord Rayleigh on the basis of the wave theory of light (which the quantum theory now aspires to supplant) had led to almost this same value for the "shadow" cast by a single atom. There are, of course, numerous hypotheses by which this large "shadow" can be reconciled with the data suggesting that the individual quantum must be very small. For example, the quanta may be attracted by the atoms when they fly near enough to them. But, evidently, neither the quantum theory nor the wave theory is yet perfect.

---

* From a statement issued by the Westinghouse Electric and Manufacturing Company, for release September 5, 1925.

*See, for example, "New Theories of Ether Waves," Popular Radio for August, 1925, page 168.

†"The Theory of Reaction Rate," by Gilbert N. Lewis and David F. Smith. *Journal of the American Chemical Society* (Easton, Pa.), vol. 47, pages 1508-1520 (June, 1925).

WHAT READERS ASK

CONDUCTED BY HUGH S. KNOWLES

In *justice to our regular subscribers a nominal fee of fifty cents per question is charged to non-subscribers to cover the cost of this service, and this sum must be inclosed with the letter of inquiry. Subscribers' inquiries should be limited to one question or one subject.*

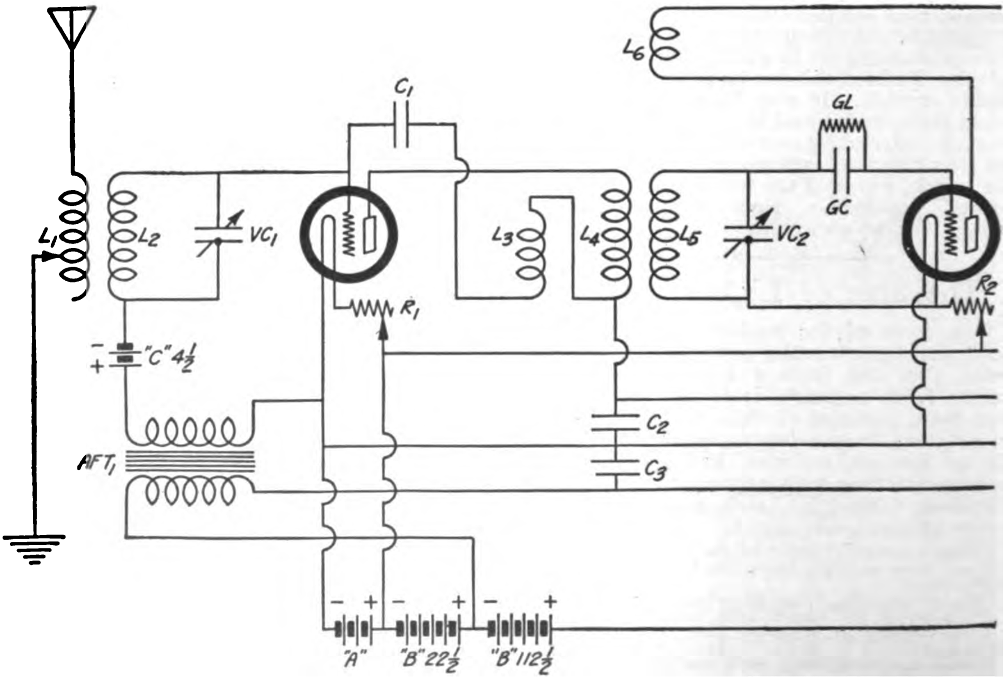
The Four-tube Roberts Circuit

QUESTION: Please give me a diagram showing how to hook-up the four-tube Roberts receiver with a stage of push-pull amplification. I have all the coils, but would like to know the proper size for the other instruments to be used in the circuit. Also please furnish me with a list of parts.

ERNEST VAN BROOKS

ANSWER: Figure 1 shows the hook-up for the Roberts circuit. It consists of one stage of radio-frequency amplification (neutralized), vacuum detector (regenerative), one stage of transformer-coupled amplification (reflexed), and one stage of push-pull audio-frequency amplification. The parts you will need for building this circuit are the following:

L1, L2, L3, L4, L5 and L6—primary, secondary, compensating plate circuit, detector grid circuit and detector plate circuit coils respectively of the Roberts kit;
VC1 and VC2—variable condensers, .0005 mfd;
C1—neutradon condenser;
C2—mica fixed condenser, .005 mfd.;
C3—mica fixed condenser, .0025 mfd.;



GC—mica fixed condenser, .00025 mfd.;
GL—variable grid-leak;
R1, R2 and R3—filament rheostats, 20 ohms;
J1—double-circuit jack;
J2—single-circuit jack;
AFT1—audio-frequency amplifying transformer;
AFT2—input push-pull transformer;
AFT3—output push-pull transformer.

There are two "C" batteries, one of three volts and the other of 4½ volts, used in the receiver. It is recommended that standard tubes of the UV-201-a type be used. The voltage of the "A" batteries will then be 6 and the voltage for the "B" batteries as shown 135 volts.

A "Hard" Detector for This Four-circuit Tuner

Question: I have one of the five-tube, four-circuit tuners described in the October 1924 issue of Popular Radio. I want to change to a UV-201-a detector. I have had considerable trouble securing good UV-200 tubes and would also like to reduce my filament consumption. Can this be done? E. T. Loock

Answer: Although this change is not generally recommended it may be worth while in your case. The grid-leak should be connected to the positive "A" battery lead. These tubes show a marked tendency to oscillate with the normal grid bias secured with a negative leak return. With a positive return the tube is operated on a better portion of the grid-current, grid-voltage curve giving better detection. You may find voltages as high as 22½ volts good on the detector particularly on loud signals. A 20-400 type Dublwundr should be used instead of the 6-400. If one of these is not obtainable use a separate 20 or 30-ohm rheostat on the first tube leaving the potentiometer circuit of the Dublwundr connected.

A "B" Battery Eliminator

Question: Is it possible for me to make a really satisfactory "B" battery eliminator, one that will get rid of all the A.C. hum and not be too bulky? Thomas J. Bowan

Answer: Yes; experiments in our laboratory have proven the possibility of this. High grade materials, the correct electrical constants and some neat wiring ability will enable anyone to make one of these convenient adjuncts to a radio set. Mr. Cockaday gives complete details in this issue of Popular Radio.

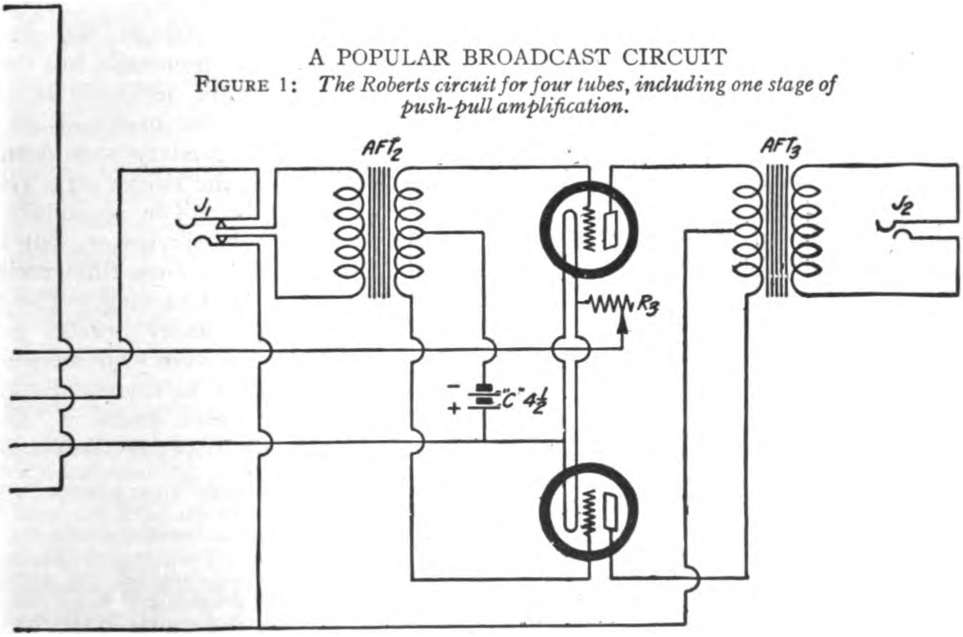
Two Sets on One Antenna

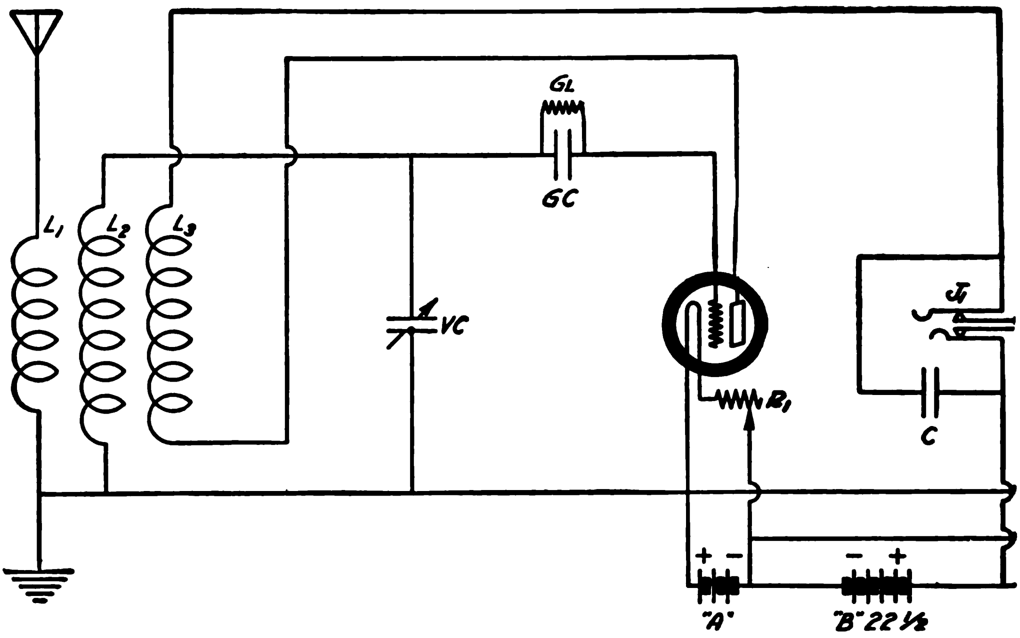
Question: Can two radio sets use the same aerial? Fred Pulen

Answer: As a rule this is decidedly not satisfactory. In the case of two regenerative receivers the radiation from each receiving set tends to produce squeals and howls in the other. With some circuits used in a few sets it can be done.

A POPULAR BROADCAST CIRCUIT

Figure 1: *The Roberts circuit for four tubes, including one stage of push-pull amplification.*





Hook-up for Three-circuit Coupler and Two Stages of Audio-frequency Amplification

Question: Please give me a diagram containing the connections for a standard three-coil coupler tuned with a single variable condenser, with two stages of audio added to it so that it will operate a loudspeaker satisfactorily.

Robert Saunders

Answer: You will find the circuit requested in Figure 2. This makes a satisfactory set with three tubes. The parts you will require for construction are the following:

L1, L2 and L3—primary, secondary and tickler coils of a standard three-coil coupler;
VC—variable condenser, .0005 mfd.;
C—mica fixed condenser, .0005 mfd.;
GC—mica fixed condenser, .00025 mfd.;
GL—variable grid-leak;
J1 and J2—double-circuit jacks;
J3—single-circuit jack;
AFT1 and AFT2—audio-frequency amplifying transformers;
R1—filament rheostat, 6 ohms;
R2 and R3—filament rheostats, 20 ohms.

It is recommended that you use a UV-200 or a C-300 tube for the first tube, which is the detector. For the second and third tubes, you may use any standard tube of the hard type.

If the set is to be employed for portable use—three C-299 or UV-199 tubes may be inserted, with a 4½-volt "A" battery instead of the usual 6-volt storage battery.

How to Make the Higher Waves Come in Stronger

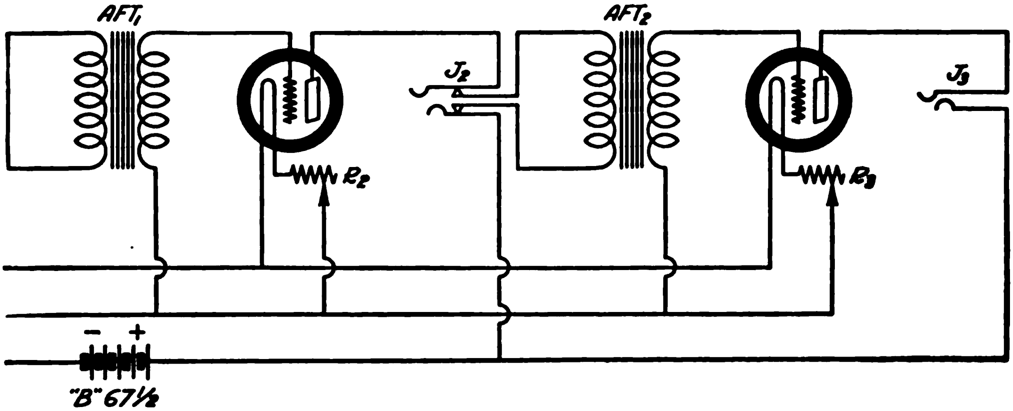
Question: I have a three-circuit regenerative receiver which gives wonderful results on the low wavelength stations, but even the local stations operating above 400 meters are weak. They can all be heard, so apparently the set is capable of tuning high enough, but those above 400 meters are decidedly lacking in volume. The coupler used consists of a primary and a secondary wound on a bakelite tube, with the tickler on a rotor inside of this tube. The secondary is tuned by a variable condenser, but the primary is not tuned. I use this receiver with an antenna 57 feet long. The selectivity and tone quality are so good that I would like to have your advice as to what can be done to correct the lack of volume on the higher waves.

Stanley Scofield

Answer: Undoubtedly your antenna is too short to give proper results with this receiver. The primary winding is semi-aperiodic and is not strictly untuned. True, you do not tune it in operating the receiver but the antenna circuit, including the primary coil, has a natural frequency to which it responds better than to other frequencies. As the primary coil and

A STANDARD CIRCUIT FOR LOUDSPEAKER RECEPTION

FIGURE 2: *This diagram gives the correct hook-ups for two stages of audio-frequency amplification when used in connection with a standard three-circuit coupler.*



your antenna are both comparatively small, the natural frequency of the combination is such that it is broadly tuned to a low wavelength. As you go above this wavelength it follows that the signal strength will drop off. If you can increase the length of your antenna to 100 or 125 feet we would advise you to do so. If this is not convenient you can improve results by connecting a variometer between the antenna and the receiver. This will help you to tune the antenna circuit to any wavelength desired. Or a coil and condenser may be used in place of a variometer. In such a case, connect the coil between the antenna and the receiver, then connect the stator plates of the variable condenser to the antenna and the rotor plates to the ground. The coil may consist of 40 turns on a three-inch form, preferably tapped every ten turns. The variable condenser may be one of .0005 mfd. capacity.

Meters for Experimenters

QUESTION: I have reached the stage in the radio game where I am not satisfied to build a receiver and then sit back and listen; I like to fuss around, and I am gradually building up a small laboratory. By experimenting I hope to gain a better understanding of the principles employed in radio. What I particularly want right now is to purchase some meters for use in making various measurements of voltages and currents. I cannot afford to go into this too heavily, but could afford two or three fairly good meters. Can you suggest two or three meters which would be most useful to me in my radio experiments?

I can't afford extremely costly instruments; for that reason I would like to have you tell me the most useful and most commonly used meters that a student should have.

HENRY BRADBURN

ANSWER: Your move is a wise one, as there is nothing of greater assistance to the experimentally inclined radio fan than suitable meters, not only in enabling him to keep his receiver battery equipment up to date, but also to enable him to study the electrical requirements of receivers, vacuum tubes and other apparatus. Our first choice of meters would be a voltmeter with a double range. Suitable ranges are 0 to 7 and 0 to 140 volts. This meter is used for measuring filament voltages, battery voltages and other equipment. Our second choice is a milliammeter with a range of 0 to 25 milliamperes. Such a meter is useful in measuring the "B" battery current consumption of a tube or a receiver. Few sets require over 25 milliamperes for the plate supply; therefore this range is adequate. Third choice falls to an ammeter with a range of 0 to 3 amperes. This is used in measuring the filament current consumption of a single tube, or of an entire receiver. By its use one can safeguard against turning rheostats too high and thus providing greater than the rated current to the filament with a resulting decreased life of the tube.

Fred Smith

BROADCASTING A GENUINE GYPSY DANCE

The enterprising "Radio Barcelona" station in Spain goes out into the highways and byways for its programs; note the microphone that is picking up the music of the gypsy dance during the "Verbena holiday" in the open square at Barcelona.

The BROADCAST LISTENER

Comments on radio programs, methods and technique —from the point of view of the average fan

By RAYMOND FRANCIS YATES

A Chance to Earn $20.00

SOMETIMES we think of throwing our better judgment (it may be bad judgment, but it is the best we have) to the winds and being like the East Side belle at Coney Island who just naturally and spontaneously labels everything "swell." It is easier, you know, to write a department reeking with whipped cream and toilet water than it is to sit down and prepare a long line of hoke which may or may not fall into that category of literary belly-aching called criticism. However, aside from our having suffered with a ripe-tomato throwing complex since the early age of five, we firmly believe that radio broadcasting can be vastly improved, which, after all, is not a strange or ridiculous hypothesis.

There is a charming trait in American people which causes them to overlook the shortcomings in many things, and the radio is no exception. We believe that said "charming trait" is a potential danger to the growth and artistic expansion of air entertainment in that our studio managers, in place of being constantly reminded of the extraordinarily punk job they are doing, are permitted to feel that they are the generalissimos of a new and highly efficient fountain of culture and entertainment. As a matter of fact, they are nothing of the sort. And this quivering old hand has not the courage to say that it can show them wherein they err. It is you, Dear Reader, with your superheterodyne and neutrodyne, who must tell our cocky studio directors where they get off. What's more, we have a dark plan to incite you to do that very thing.

We want you to outline for us what you believe to be a perfect radio program—the very kind of a program that you would like to hear. Save that the letters must be in this office within thirty days after the publication of this issue of POPULAR RADIO, there is not another condition. If paper is scarce, write on both sides, we don't care.

A reward of twenty dollars will be paid to the writer of the most practical and well-balanced program. The writers of the three next best letters will receive an autographed copy of a book on broadcasting that we once wrote with Roxy.

Incidentally, if the program is real good we shall make a brave effort to have it broadcast here in New York. We have been challenged by the studio managers many, many times, and it is about time we delivered something more tangible and useful than a sarcastic spasm of very bad English.

* * *

The Chicago Listeners Strike

AMONG the very funny things that have happened in broadcasting during the last three years, the threatened strike of the long-distance fans in Chicago is perhaps the funniest. We wouldn't be a bit surprised if it was not a lot of newspaper noise, but then, of course, who would blame the listeners in Chicago for threatening not to listen to programs that are unworthy of Rahway, N. J.? However, it seems that it is not quality but quantity that is of greatest interest to those who are kicking up the fuss. From all indications a noisy group of long distance cranks who yap over their records like silly school kids, want all of the broadcasting stations in Chicago to close shop one night in each week while they paw over the etheral wares of the country.

Things are coming to a pretty pass when a bunch of idiots set out to prevent the sensible people in Chicago from listening to their local stations. Yet, aided by the newspapers, they seem to be making out quite a case for themselves and we should not be a bit surprised to find them in the end victorious. After all it is the squawker who wins his point in the long run.

* * *

Studio Sheiks

FOR a long time (oh, it must be all of five months) we have been debating on the advisibility of compiling and publishing a deep scarlet exposé involving two of every three radio announcers in these United States of America. At a special conference held in our great big luxuriously appointed Directors' Room at the POPULAR RADIO headquarters, it was recently decided to tell the public of this country a thing or two about its salad-eating heroes in the studios. The dirty nature of this exposé must be excused as part of our general campaign for more intelligent announcing and program administration.

How anybody with anything but a warped sense of esthetic values can relish and even revel in the literary flapdoodle so freely peddled by the average sleek-haired station ballyhooer is far more than our research department has been able to fathom. However, be that as it may, our present unpleasant task is to prove that our radio studios are in the majority of cases manned by a lot of skirt-crazy dullards with a strong leaning toward Stacomb and Sixth Avenue Russian cigarettes.

What our studios need more than anything else in the world (and we have a lot of things in this world, haven't we?) are men who have survived their flirtatious days; men who are not rendered mentally ***hors de combat*** by the mere appearance before the microphone of a sparingly dressed blond soprano or a goo-gooed-eyed brunette. We're a pretty wise old owl when it comes to sampling the atmosphere of any particular place and we know whereof we speak. If just about fifty percent of our studio sheiks were permitted to go back to the soda fountains from which they came or from which they should have come, the improvement in announcements would be immediate and big. We need men who have settled down; men engaged in the serious business of making a livelihood for their families; men with enough experience in life to make them want to create sympathetic understanding and

Kadel & Herbert

DELIVERING THE SOUNDS OF BROADCASTING TO MAIN STREET

What is claimed to be the largest radio microphone in the world is owned by station WOR, of Newark, N. J. It is an exact duplicate of the smaller "Mike," but inside of it there are six of the small type. It stands out of the window of the New York studio of the station, and on occasion it is used to pick up the noises of the Gay White Way for broadcasting.

not a mere "impression." Our sheiks are so bent on soliciting "mush notes" from high-school girls and nutty old women who ought to know better that they are oblivious to the niceties that go to make up proper and intelligent conversation. The average announcer leads a "microphone life" which is so far removed from his normal routine of living that he makes himself ridiculous every time he opens his mouth to the audience. When one side of a man's life is intended to reveal Oxford, Harvard or Dartmouth, and the other side requires only the simple rudiments of life so beautifully supplied by Public School No. 23, that man cannot help but expose the Public School No. 23 side every time he attempts to display the Oxford or Harvard side. That is as sure and as inevitable as the great big red nose on our face.

If you see us marching down Fifth Avenue some day with a big banner saying, "Kick the Sheiks out of the Radio Studios," you will know that we are terribly serious about this matter and that correct announcing is the passionate part of an old body that has very few other things to be passionate about.

Pacific & Atlantic

THE "WORLD'S CHAMPION RADIO FAN"

This is the title conferred on W. D. Johnson of Cambridge, Mass., by the American Radio Relay League at the close of its convention in Chicago on August 21. Mr. Johnson walked and rode a bicycle all the way from his home to the Windy City to attend the gathering.

Is "Studio" Correct?

ANYTHING that grows as fast as broadcasting has grown usually forgets to do a lot of things that it should have done. One of these things, and one that has worried this old busybody a great deal, is the term "studio." Doesn't a "broadcasting room" come a little closer to meeting the requirements of a theater than a "studio?" Can a place sheltering a public performance, even though the performance be invisible, be properly called a "studio?" If we are displaying an undue amount of ignorance in this matter we should like to be corrected by some of our more intelligent and enthusiastic readers.

* * *

Some Pretty Bad Stations

THE American public probably falls easier than any other public in the world; you can sell it orange juice made of rank organic acids, plays soaked in the very essence of obscenity, periodicals crammed with the hottest kind of bunk, newspapers slimy with scandal, prize fights as fixed as the Belt of Orion, baseball heavy with business conspiracy and movies so full of diabolical rot and suggestive situations that they transcend even the hoochie-coochie of the old-time circus. Is it any wonder that this same public has tolerated the measly effort of eight out of every ten of our broadcasting stations?

An impartial critic must admit that we have but thirty-five or possibly forty broadcasting stations that are actually trying to lift broadcasting to the plane of a decent source of American entertainment. Take out WJZ, WGY, WEAF, KFI, WOR, WRAC, WGR, WLW and a few others of similar caliber and you have nothing left but a series of cheap hangouts for jobless small-time vaudeville performers, industrious song pushers, parlor boobs, hopeless pupils of honorless music teachers, nutty reformers, quack health doctors and Kiwanas Club lecturers.

* * *

The Poor Announcers Again

WE'RE getting along in years now and we really should take a more kindly attitude toward many things, especially announcers. But it is pretty hard to break bad habits and so we might just as well let the evil spirit take its course.

It often happens in broadcasting from restaurants, hotels and the like that the orchestra requires a little rest and that the announcer is called upon to fill in the interim with more or less illuminating remarks concerning this or that. A great deal of research on the subject has proven that the average announcer (and it seems that nearly all announcers, like ice men and waiters, are average or so close to average that you can't tell the difference) has a difficult time being illuminating about this or that. Give 99 out of every 100 announcers five minutes of their own in which to hold the attention of the radio audience and they will invariably commit oratorical hari-kari in the first 27 seconds. We have misplaced our notes on the matter, but we believe it is eleven times

Kadel & Herbert

BROADCASTING SEVENTH-DAY ADVENTIST DOCTRINES

Another and more powerful transmitting station has been installed in the City Temple of New York (WSAP) for the purpose of spreading the propaganda of this sect.

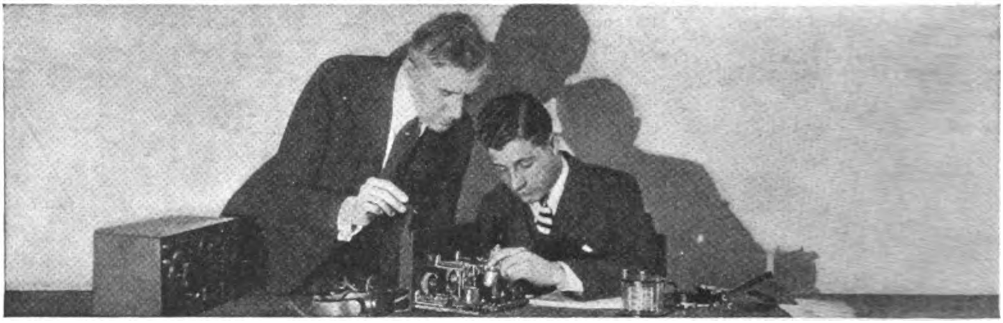
that we have listened to a dramatic account of how Schubert jotted down the theme of a great masterpiece on the menu in a dimly lighted Bohemian *rendezvous*. Indeed the tragedies in the lives of all of the great masters are as familiar to us as the story of Little Red Riding Hood and Charlie Chaplin's latest *affaire de coeur*. Yet announcers have standardized on this sort of "fill-in" material, so what are you going to do about it? It's a pity that they cannot be a little more practical about using this valuable time now that the country knows what inspired Massenet's "Elegie" and how Bach won his musical spurs at the clavichord thousands and thousands of moons before Berlin and Cadman squeezed out of their musical souls such astounding hits as "Bebe" and "At Dawning." A few baseball scores, a few news items or a harmonica solo by one of the youngsters of Public School 57 would fill the bill beautifully as far as we are concerned and it would give the announcers the opportunity of saving their list of superlatives for general purposes. Let those who will dramatize the lives of musicians but we feel pretty sure that's no job for our studio men, big and learned as they are.

* * *

The Good Ship *Bossert*

If we should be crowded into a corner and pressed real hard for an expression of opinion as to the greatest broadcaster on the air we should almost admit that WEAF was that broadcaster. If WJZ should tighten a few loose bolts, we might change our opinion. Anyway, to say that a certain station is best is not admitting a great deal for, after all, there are not more than a few centimeters separating the worst from the best. Be that as it may, WEAF does manage at times to work in little innovations that show that somebody is doing a little thinking in the interests of better programs.

While we have not gone completely wild over the idea, it is a bit novel and refreshing to have the announcer tell you that such and such a hotel orchestra is playing from an imaginary ship and to have that orchestra start off with the ringing of ship bells and the lively strains of "Over the Bounding Main." While we are a long way past the days when we could roll ourselves up in a blanket on the daybed and imagine that we were cuddled up in a big sleigh swaying over the snow-covered hillsides, we are not so old and crabby that we cannot adjust ourselves to the notion under discussion. What we crave is originality in broadcasting and we don't mind being asked to conjure up a childish illusion to help some poor overworked impresario believe that he has hit upon a big idea. We'd gladly imagine that we were a teddy bear and go snoofing under the sewing table for a bumble bee nest if it came right down to the matter of encouraging originality on the air. If you are "looking" about some evening for something light and good just try the good ship *Bossert*.



IN THE EXPERIMENTER'S LABORATORY

CONDUCTED BY LAURENCE M. COCKADAY

A Short-wave Receiver

LIST OF PARTS—

L1—Antenna inductance coil; (see below for construction data);

L2 and L3—Closed circuit inductance coil; (see below for construction data);

L3—Choke coil; (see below for construction data);

VC1—Cardwell variable condenser, .0001 mfd. capacity (7 plate);

VC2—Cardwell variable condenser, .00025 mfd. capacity (11 plate);

R1—Amsco rheostat, 30 ohms;

R2—Daven grid-leak; best resistance should be determined in each individual case; a resistance of 4 megohms is usually correct);

S1 and S2—Na-ald sockets No. 499 for UV-199 or C-299 tubes;

J—Single circuit, filament control jack;

AFT—Thordarson audio-frequency transformer, ratio 3½ to 1;

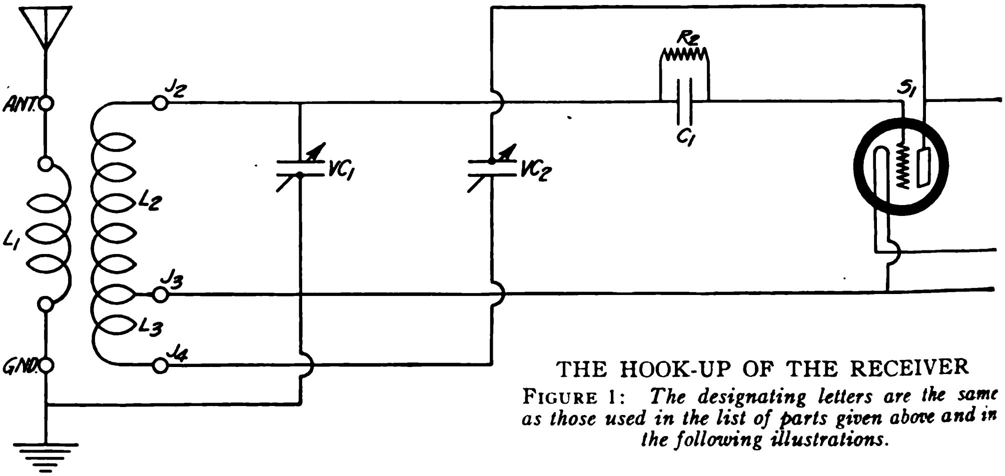
C1—Sangamo fixed condenser with clips for grid-leak mounting;

J2, J3 and J4—General Radio coil mounting jacks, No. 274J;

Miscellaneous—composition panels, 2 pieces 5 inches by 3½ inches for mounting the variable condensers; 1 piece 26 inches by 1 inch to be cut up for binding post strips, coil mounting, etc.; 9 Eby binding posts; 12 inches of ½ inch by 1/16 inch strap brass; bus wire; baseboard 17 inches by 8½ inches; 1 lb. No. 16 DCC copper wire; ¼ lb. No. 28 DSC wire; 9 General Radio coil mounting plugs No. 274P.

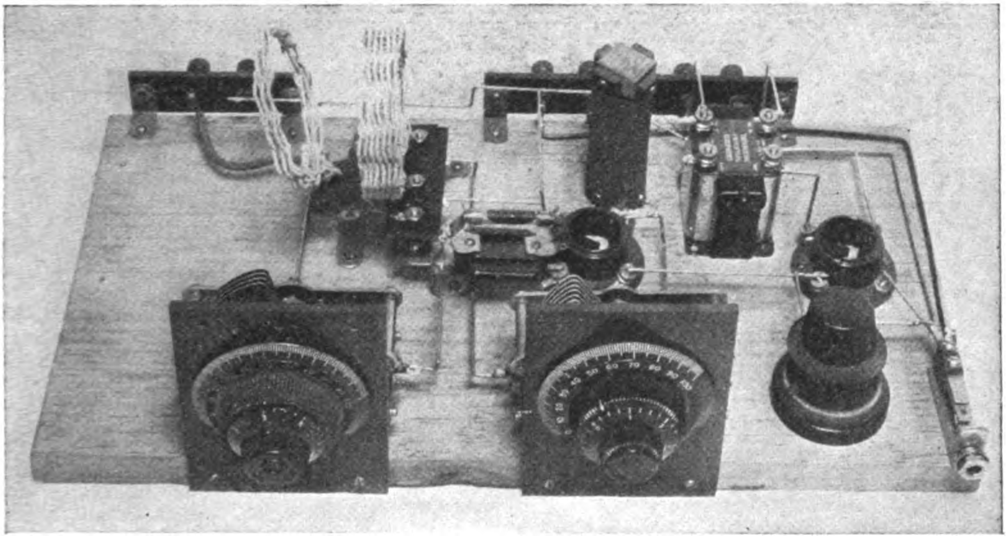
SHORT-WAVE reception—that is, on wavelengths under 100 meters—is in its infancy, so far as broadcasting is concerned. But there is every indication that it is going to grow fast.

During the past winter several of the large



THE HOOK-UP OF THE RECEIVER

FIGURE 1: *The designating letters are the same as those used in the list of parts given above and in the following illustrations.*



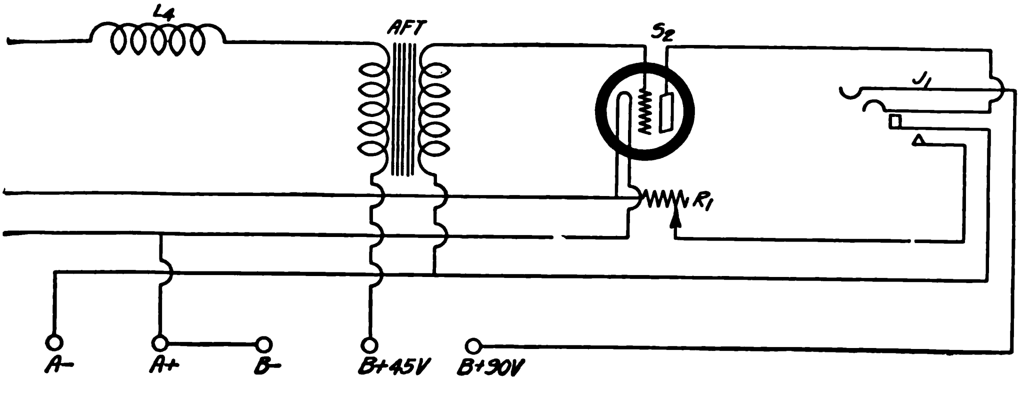
THE FRONT VIEW OF THE RECEIVER

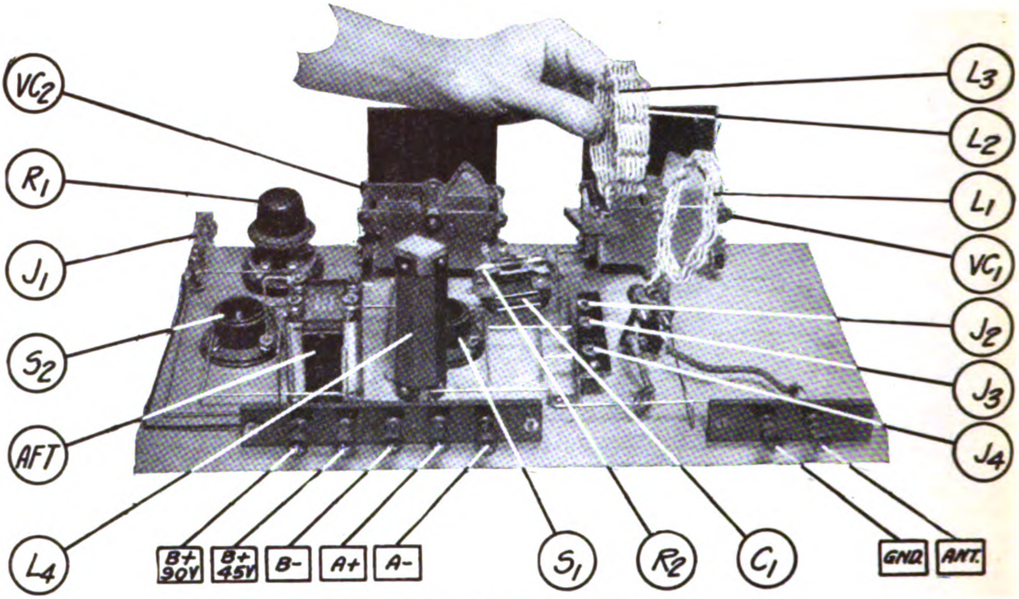
FIGURE 2: *In this and in Figure 3 a clear idea of the layout of the various instruments may be obtained. The wavelength tuning is accomplished by means of the left-hand dial, while regeneration is controlled by the one at the right.*

broadcasting stations have been transmitting their programs simultaneously on their regular wavelengths and on short waves around 100 meters or lower. Current reports indicate that this fall there will be a network of broadcasting stations all the way across the continent, that will follow this practice.

Many radio fans, whether they be dyed-in-the wool experimenters or simply broadcast fans, are playing with the idea of short-wave reception because the short waves have opened up a large and promising field for experiment, and also because broadcast reception on the short waves has some remarkable features. Surprising distances can be covered during the daytime on wavelengths around 50 meters and lower. Static interference is decidedly less than on the regular broadcast wavelengths and exceptional DX reception is possible. The simple receiver described here, using a detector and one stage of audio, frequently brings in KDKA with sufficient volume to operate a loudspeaker during the summer months, even though it is in operation about 300 miles from Pittsburgh. This station operates on a wavelength of sixty odd meters. At times during the summer when static on KDKA's regular wavelength of 309 meters was so bad as to make reception unsatisfactory, they could be heard clearly on the short wavelength with no trouble from static. This is not always true, but it is certain that static is less troublesome on the short waves than on the regular broadcasting band.

When the new short-wave transmitter in California is put into operation in the fall there is every reason to believe that a simple two or three-tube short-wave receiver on the Atlantic coast will bring this station in with much more certainty than a multitube receiver operating on wavelengths greater than 300 meters. It is a proven fact that amateur continu-

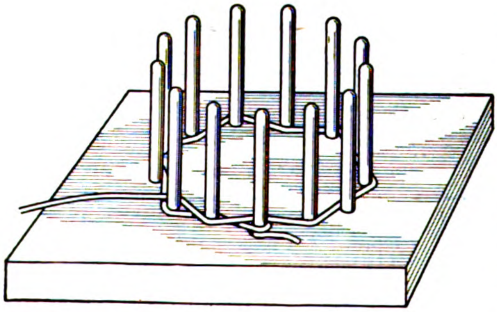




THE REAR VIEW OF THE SET

FIGURE 3: *The symbols used correspond with those in Figure 1 and in the list of parts. The proper connections for the antenna, ground and batteries are shown. Note that the secondary coil is just being plugged into the receiver, by means of the plugs on the coil and jacks J2, J3 and J4.*

ous wave transmitters operating on the short waves, and using only a fraction of the power used on broadcasting stations, have carried on reliable communication between California and New England at midday. The receivers used in these tests were no more elaborate than the one described here. Of course, both the transmitters and the receivers were highly efficient, but the main credit for this remarkable bit of work belongs to the inherent qualities of the short waves as a medium for radio work.



THE COIL WINDING FORM

FIGURE 4: *This is the winding form for winding the air core coils; dimensions will be found in the text. The pegs may be metal tubing, wood dowels or any other fairly strong material; solid metal rod is probably the most satisfactory, however, as it does not burr or split at the ends as is sometimes the case with tubing or wood, when it is necessary to use a hammer to force the pegs in and out of their holes.*

The layout of the instruments on the baseboard is clear from the illustrations, Figures 1, 2, 3 and 4. The coils may easily be made at home in the following manner:

The choke coil consists of 200 turns of the No. 28 DSC wire, wound on a tube 1¼ inches in diameter and 4 inches long. The choke coil shown in the illustration was wound on a form made up of four ½-inch strips of hard rubber, thus making a semi-air-core coil. Cardboard tubing which has been given two coats of shellac will serve the purpose quite satisfactorily, however.

The coils for the antenna and closed circuits are of the air-core type, wound on a form as shown in Figure 4. It will be necessary to make three closed-circuit coils to cover the different wavebands up to 90 meters. Larger coils can be made to cover wavelengths above this range if desired.

For the antenna circuit two coils should be made. One should have five turns, for use in reception up to about 60 meters, the other should have 10 turns for waves higher than this. If the antenna used is a long one, however, the five-turn coil will be enough, and even with this small coil it may be necessary to use a .00025 fixed condenser in series with the antenna.

The winding form is made by laying out a circle 3 inches in diameter on a piece of 1-inch board, and then laying off 13 equidistant points on this circle. At each of these points drill a hole through the board for the pegs which are to be used for the coil form. These pegs may be made of 3/16-inch metal rod, or they may even be large sized nails, although the rough surface of the latter is liable to scrape the insulation off the wire. The holes should be slightly smaller than the pegs so that the pegs will be rigid when driven into place. After the pegs are in place (if the holes have been made sufficiently snug it will be necessary to hammer them in) the five-turn antenna coil may be wound as a starter.

The No. 16 DCC wire is first looped around one of the pegs. With the board flat on the table and this peg nearest the body, start the winding toward the left. With the wire coming around the outside of the first peg, run it inside of the next peg to the left, outside of the next, and so on. Because of the odd number of pegs it will be found that the second turn of wire passes on the inside of the peg at which the winding was started, outside of the second peg, and so on. After five complete turns have been wound on the form, slide the whole coil up a little on the pegs, *after* looping the end of the winding around the same peg that the beginning was looped around, and cut the wire with a couple of inches of free end.

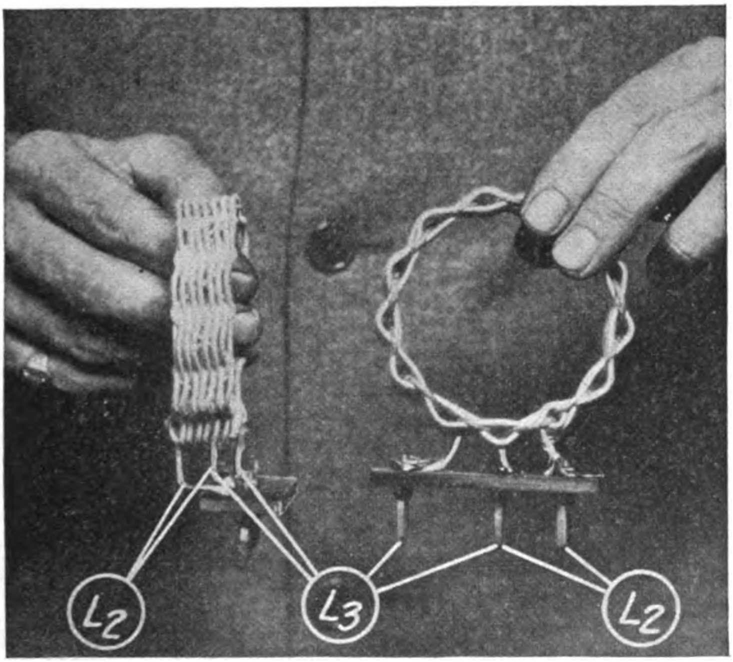
Now remove this first peg by pushing a nail up through the hole in which the peg rests. Next run a piece of cord down through the hole (in the coil) left by the peg, and tie the end of this cord tight so that the coil will retain its shape.

Next, remove another peg and run the cord up through the hole in the coil, remove the next peg and run the cord back down through this hole, and so on. Thus when all the pegs have been removed the coil will be held securely in shape by this lacing.

For greater security, especially in the case of larger coils, the lacing can be continued until it has gone around twice. After tying the end of the lacing cord, the first antenna coil is completed. Another coil of ten turns may then be wound in the same manner.

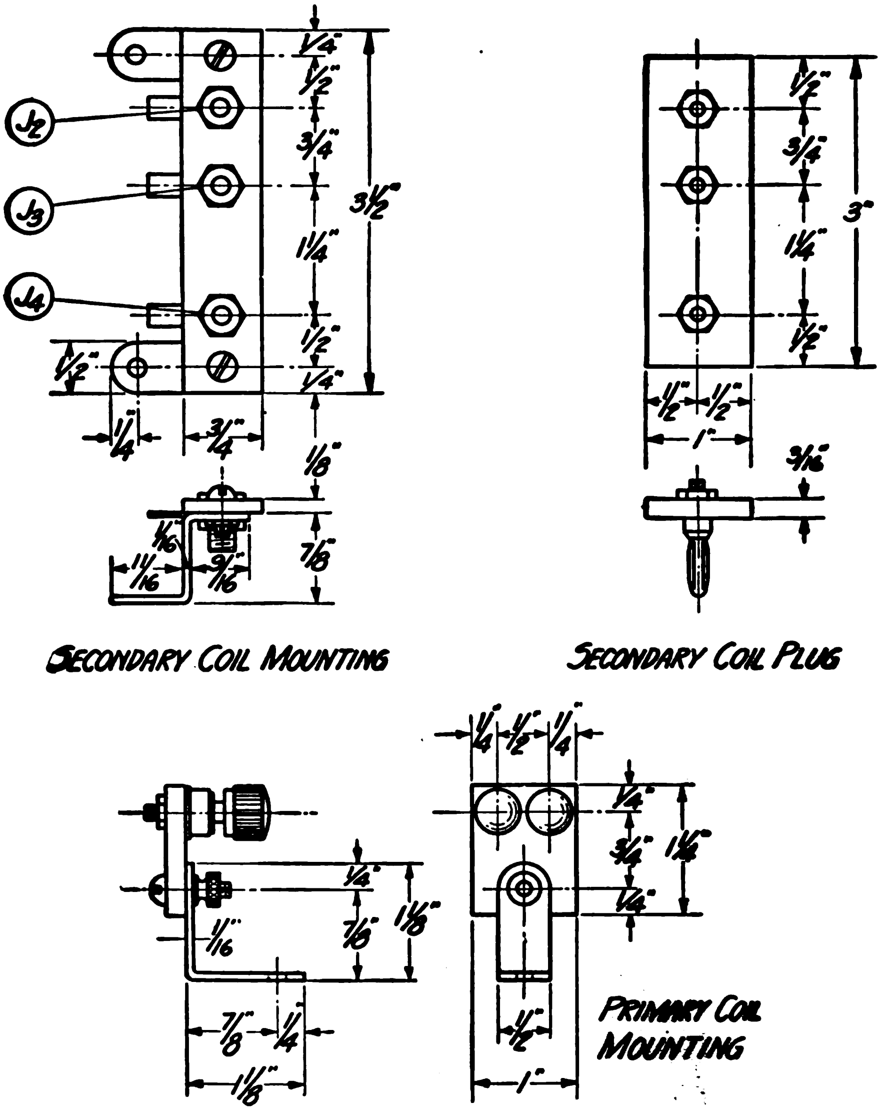
The tapped coils for the closed circuit are wound in the same general way. The first coil, to cover the wavelength band from 12 to 30 meters, consists of five turns, with a tap at the second turn. The winding is started as before and continues for one complete turn and around again to the peg before the one on which the winding was started. Here the tap is taken off, then the winding is continued two complete turns and on to the peg before the one at which the tap was taken. The lacing and removal of this coil is the same as described above. The two turns make up the plate inductance (L3-Figure 5) while the larger part is the grid inductance (L2).

The next larger coil is wound in the same manner and consists of nine turns, tapped at the third. The third coil consists of 18 turns,



FRONT AND SIDE VIEW OF THE COILS

FIGURE 5: *Two of the coils are shown here, all mounted and ready for use. Note that the three plugs are unevenly spaced; this is also true of the jacks into which the plugs slip. This is done to prevent plugging the coil into the receiver backwards.*



DETAILS OF THE MOUNTINGS FOR COILS

Figure 6: *The primary and secondary coil mountings are secured to the baseboard of the receiver as shown in Figures 2 and 3. The bolt and nut in the middle of the primary mounting permit swinging the primary coil to and from the secondary coil, thus permitting just the proper degree of coupling between the two. The method of mounting the coils on the secondary coil plug is shown in Figure 5.*

tapped at the sixth. By means of these three coils the entire band from 12 meters up to 90 meters may be covered. To go higher than this a coil of 36 turns, tapped at the twelfth turn is suggested. In each case the larger portion of the coil represents L2 in the hook-up, or the grid coil.

Tuning is so sharp on these low wavelengths that the use of a low capacity tuning condenser is essential. If a .00025 mfd. variable condenser is used for VC1, instead of the .0001 mfd. condenser specified it becomes difficult to find and tune in signals, as even when the dial is turned slowly stations are liable to be skipped over unnoticed.

The mounting of the coils is the next step in the preparation of the receiver. Due to the comparatively small wavelength range of each coil, it is first of all necessary to arrange for quick change of the closed circuit coil. Also, the antenna coil must be mounted in such a way as to permit swinging it to and from the closed circuit coil, to vary the coupling between the two.

For the closed circuit coils a fixed mounting is provided on the baseboard, provided with three small jacks. Then each of the closed circuit coils is mounted on a small composition strip by means of three of the General Radio coil plugs. The plugs are mounted on the strip as shown in Figure 6, and the three leads from the coil are soldered to the lugs provided with the plugs. With each of the coils provided with these plug contacts, changing coils becomes as simple an operation as inserting a phone plug in a jack.

The method for mounting the antenna inductance coils is also simple. There is, however, less occasion to change coils here so plugs and jacks are not necessary. Two binding posts serve as mountings. The two ends of the coil winding are sufficiently rigid to provide ample support when connected to these binding posts.

When operating the receiver, VC1 is the wavelength tuning control while regeneration is controlled by means of VC2. The adjustment of VC2 has practically no effect on VC1 and the receiver is surprisingly stable in operation. There is no body capacity noticeable in tuning with VC1 and the slight body capacity resulting when the hand is placed on the dial of VC2 is of little importance as this dial is not touched after a station has been brought in, all the fine tuning being done with VC1.

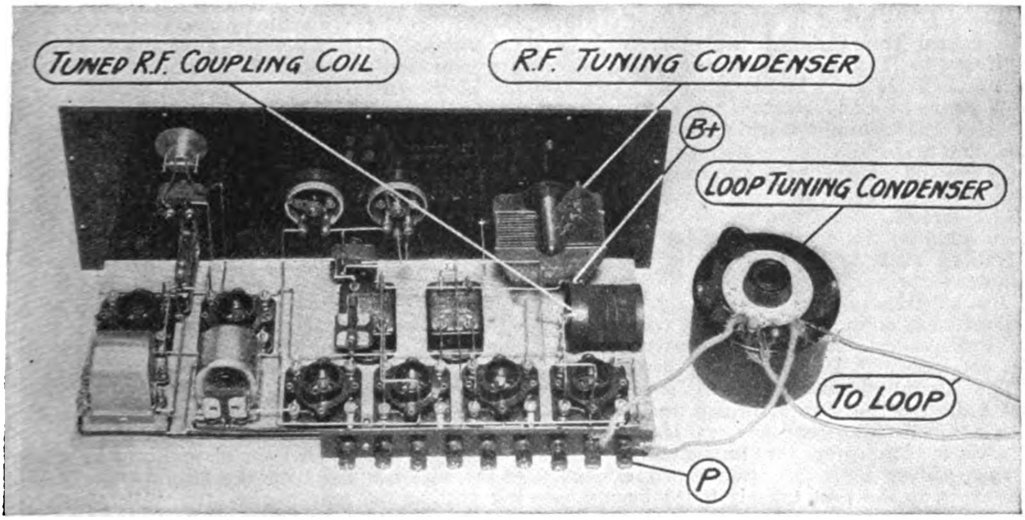
To put the receiver into operation the batteries, antenna and ground are connected.

If UV-199 or C-299 tubes are used (and they serve as well as the larger tubes for this receiver), either three dry-cells connected in series, or a storage battery may be used for the filament supply. A single-wire antenna, 50 feet in length, will serve as well as anything else for an antenna. If a larger antenna is used the coupling between the antenna and closed circuit coils must be loosened. In other words the antenna coil should be swung away from the other until the two are almost at right angles.

When the rheostat is turned on slightly and the phone plug is inserted in the jack J1, the tubes should light and the receiver is in readiness for reception. Starting at zero, turn the dial of VC2 until a "plop" is heard as the receiver goes into oscillation. Leave this dial set just beyond this point and rotate the dial of VC1. If, in rotating VC1 another plop is heard it means ,that oscillation has stopped and VC2 must be turned a little higher. When the receiver is made to oscillate with VC1 set at 100 then oscillation should continue uninterrupted throughout the entire scale of VC1. If it does not do this, it is usually an indication that the fundamental frequency of the antenna circuit is the same as that to which the receiver is tuned when oscillation stopped. The remedy is to reduce the coupling by swinging L1 further from the closed circuit coil.

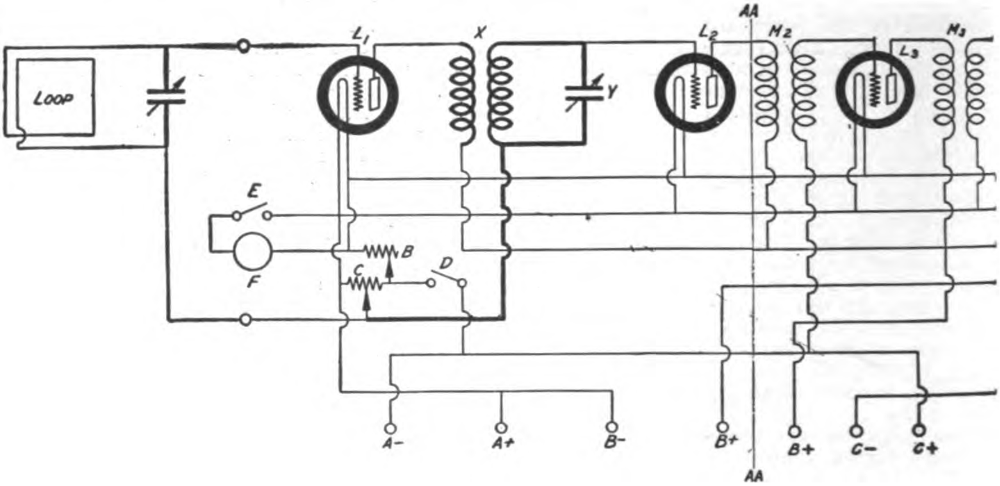
When the receiver is oscillating and VC1 is rotated slowly, a "birdie" whistle will be heard when VC1 passes over a signal. If the signal is code, VC2 should be turned back until oscillation stops and then up again just past the point where oscillation starts. This will be the point of maximum signal strength for code reception. Dial VC1 is then carefully adjusted for best results. If the signal is one from a broadcasting station then VC2 should be turned back until oscillation just stops and VC1 should be more carefully adjusted. Voice signals are best just below the point of oscillation as they are badly distorted if oscillation is permitted.

—S. Gordon Taylor



VIEW OF THE SET FROM THE REAR

Figure 7: *Here is shown the location on the baseboard of the new radio frequency coupling unit. The method of connecting the loop tuning condenser is also illustrated.*



Alterations In the "Town and Country Receiver"

It has been found that under certain conditions the "Town and Country Receiver" (described in the May, 1925, issue of Popular Radio) did not provide sufficient selectivity when used in the immediate vicinity of high-powered broadcasting stations.

To improve the receiver in this respect experimental work has been carried on in the Popular Radio Laboratory with the result that the selectivity is now sufficient for use in any location. Used in the heart of New York City, within a few blocks of several powerful stations, no difficulty is now found in separating them absolutely so that any one station may be tuned in without any trace of interference from any of the others. In a night test in New York it was found possible to tune in KDKA at Pittsburgh (309) meters without any interference from WGBS or WAHG, local stations working on 316 meters. Cleveland and Philadelphia stations were tuned in on 390 and 395 meters respectively, while the local stations WOR and WJY were working on 405 meters.

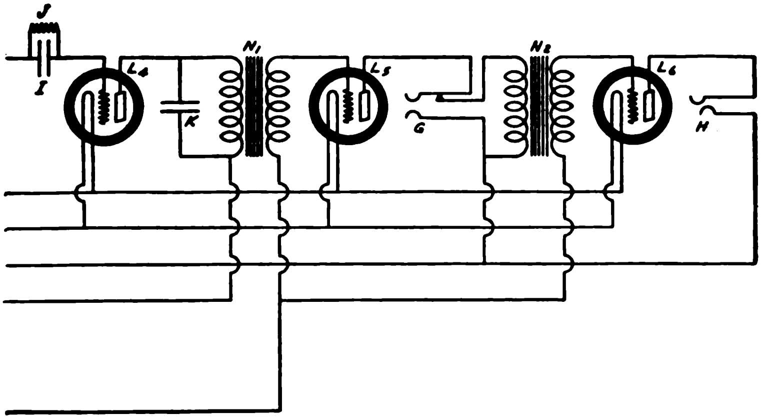
In addition to increasing selectivity, the alterations made in the receiver increased the volume surprisingly. Operating the receiver in the suburbs of New York City, the city stations were entirely too loud for comfort on the loudspeaker. Ample loudspeaker volume was obtained with the plug in the first jack.

The alterations made were simple. The first radio-frequency transformer was replaced with a tuned-radio-frequency transformer and a variable condenser for tuning this transformer. Thus there are two tuned circuits. The input to the first tube is tuned by means of the variable condenser connected directly across the loop and the input to the second tube is tuned by means of the variable condenser shunted across the new tuned-radio-frequency transformer.

First of all, the variable condenser and the first radio-frequency transformer are removed from the receiver. This variable condenser may be used for tuning the loop. It will not be mounted in the receiver proper. The new variable condenser is now mounted on the panel in place of the one just removed, using the same shaft hole.

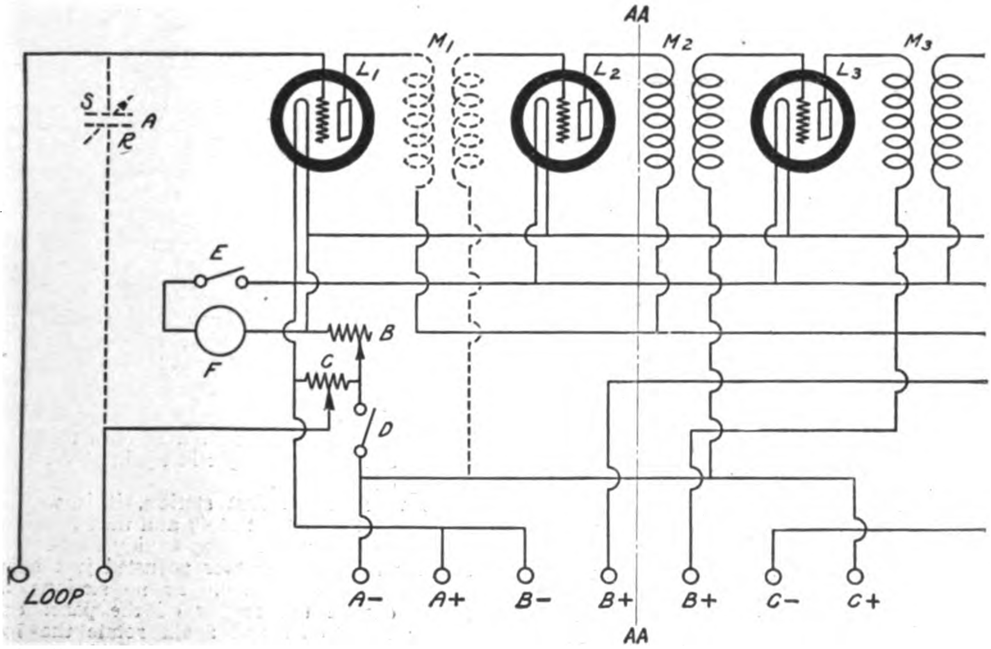
The new radio-frequency transformer is mounted at the end of the baseboard in a horizontal position between the variable condenser and socket No. 1 and with the connecting lugs pointing to the left looking from the rear of the receiver. (See Figure 7.) It should be laid with the primary connections uppermost. These are the two terminals which are connected to the small winding in the center of the transformer. The secondary terminals will then come at the bottom. The mounting is accomplished by drilling a hole through the rim of the form and between the two secondary terminals. Run a wood screw down through this hole into the baseboard. A washer about ¼ inch in thickness should be placed between the baseboard and the coil form. When mounted in this position the two terminals nearest the panel are: upper, B+; lower, F. The upper and lower rear terminals are Plate and Grid, respectively. The B+, Grid and Plate terminals are connected into the circuit the same as the corresponding terminals of the old transformer and in addition, the grid terminal also connects to the stator plates of the new variable condenser. The F terminal of the coil is connected differently, however, inasmuch as it goes to the wire running from the second loop binding post at the rear to the arm of the potentiometer. A connection from this wire goes to the rotor plates of the variable condenser.

The variable condenser which was removed from the receiver may be used to tune the loop. There is hardly enough space on the panel to



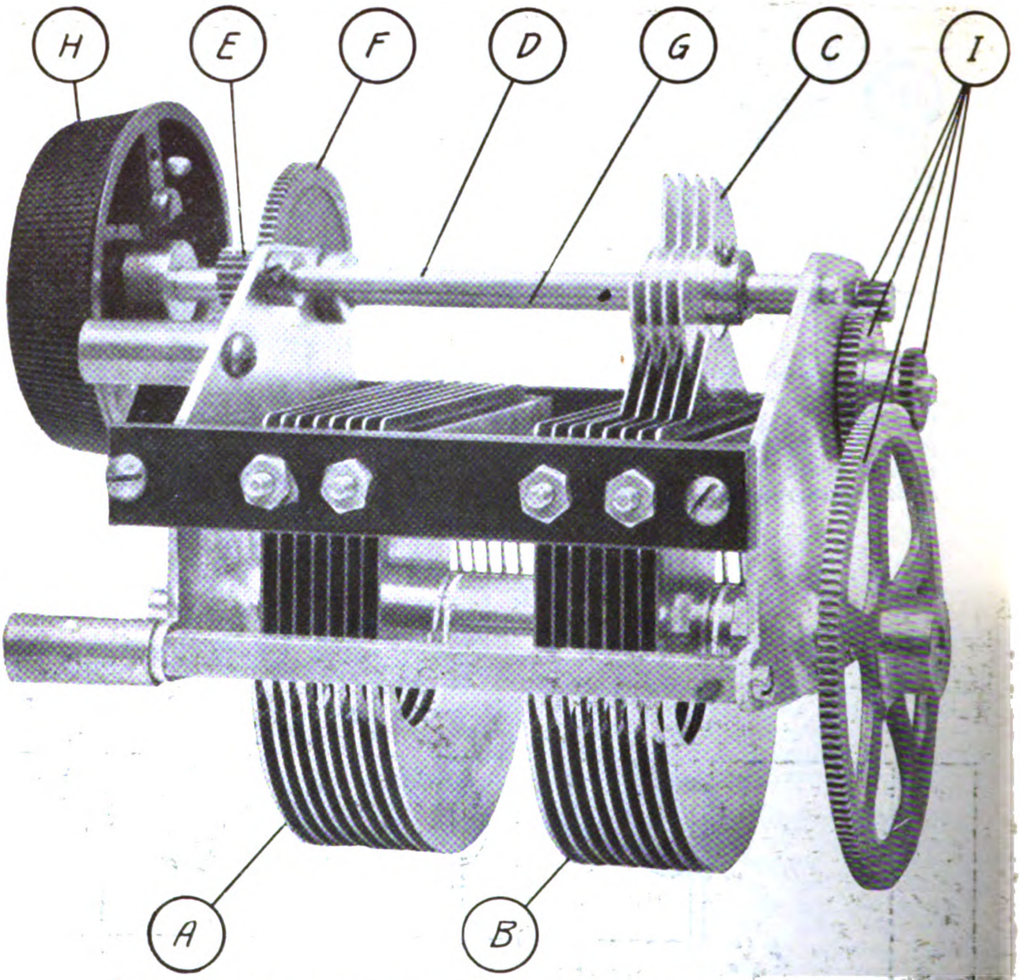
THE COMPLETE NEW CIRCUIT

FIGURE 8: *This is the same diagram as in Figure 9, except that the new instruments and connections are shown in heavy lines. The new instruments used are: (X) Precision radio frequency coupling unit, and (Y) Bradleydenser, capacity .0005 mfd. The location and use of these instruments are explained in the text.*



CHANGES IN THE HOOK-UP

FIGURE 9: *This shows the first half of the hook-up as given in the descriptive article in the May 1925 issue of* POPULAR RADIO, *but with dotted lines to indicate the instruments and connections which are to be removed. These include the transformer M1 and the variable condenser A, as well as the connection from the transformer to the filament or "A" battery circuit. (The balance of the circuit beyond AA is not shown as it remains the same as in the May issue.)*



A NOVEL IDEA FOR TUNING TWO CIRCUITS SYNCHRONOUSLY

Figure 10: *This picture shows two variable condensers controlled by a single knob. The capacity of condenser B pulsates quickly above and below the capacity of the condenser A. This is accomplished by means of the small "booster" condenser C.*

mount this condenser, so it is set up next to the loop, outside of the receiver. In the laboratory a General Radio mounted type of condenser was used for tuning the loop, for the sake of convenience, but the original condenser can be used by mounting it on a small piece of panel material, with a small baseboard to support the panel. It is connected across the two "loop" terminals of the receiver, the two sides of the condenser also being connected to the loop. The connections are shown in Figure 8. The reason for using a different condenser in the receiver is that the original condenser had a capacity of only .00035 mfd., whereas a capacity of .0005 mfd. is required to cover the broadcasting waveband with the type of tuned-radio-frequency transformer used.

Operation of the receiver is the same as before in all respects except that there are two circuits to be tuned now instead of one. Both of the dials can be "logged," however, because when a broadcasting station is once tuned in, it may always be brought in again at the same setting of the dials.

To tune in the first station, it is well to start with the dial set at 40 and then to slowly rotate the other dial (loop tuning condenser), keeping the potentiometer adjusted just below the point of oscillation. If no stations are heard, change the setting of the panel condenser dial to 35 and again rotate the loop tuning condenser dial. Repeat this process, if nothing is heard, setting the panel condenser on 30, and so on until a station is finally heard. Then readjust both condensers and potentiometer until the signals have maximum volume. The settings of the dials can then be recorded for use when it is again desired to tune in this particular station.

—S. G. Taylor

A New Idea in Single-control

It is a well-known fact, when using tandem condensers for controlling two radio-frequency stages with a single dial, that unless the two coils have exactly the same values of inductance the two circuits cannot be both placed in resonance.

I have been working for more than two years on single-control receivers with the usual type of gear condensers with success.

During 1924, however, I conceived the idea of a method of securing absolute resonance between associated circuits using one control knob. The method which I employ uses no separate vernier or other balancing devices. This method consists of turning one of the controls continuously, shifting the second control backward and forward automatically so as to "cross" the resonant position of the first control.

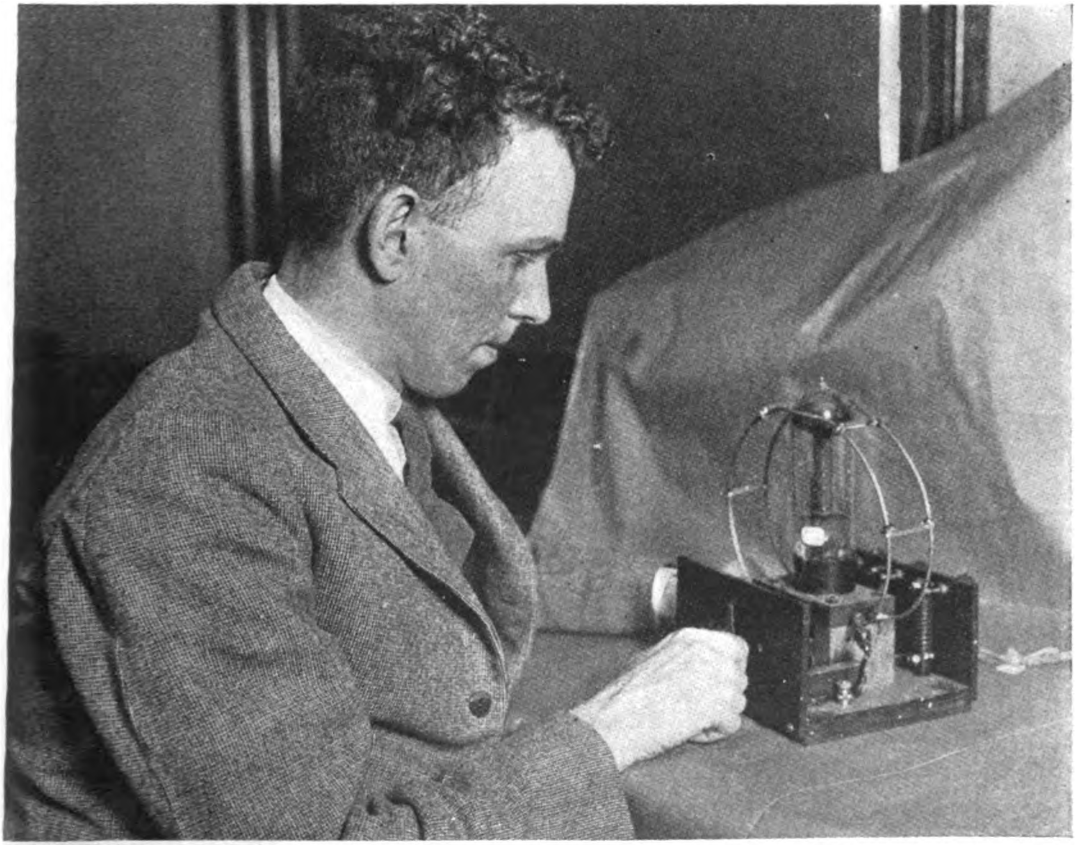
Referring to the picture (Figure 10) the small condenser marked C shown at the top of the second unit B is connected on the shaft E which is energized through the gear E which gets its motion through the gear F of shaft G operated by Dial H. The two units A and B are operated simultaneously by the gear train I, which is also connected by the shaft G to the dial H.

It will also be seen that as the two condenser units A and B are being rotated slowly the small unit C is being rapidly changed so that the resonance point of the second unit crosses the resonance of the first unit and, therefore, a point can easily be found where the two units will always be in resonance even though the coils do vary somewhat.

The ratio between the control knob and the vernier shaft on the model shown in the photograph is approximately five to one and the ratio between the control knob and the main shaft is twenty-five to one, giving a ratio of 125 of the vernier capacity to ½ revolution of the main shaft.

Owing to the fact that the vernier is of smaller capacity no trouble will be experienced in stopping the control knob at the exact resonant point for any stations.

—T. E. New



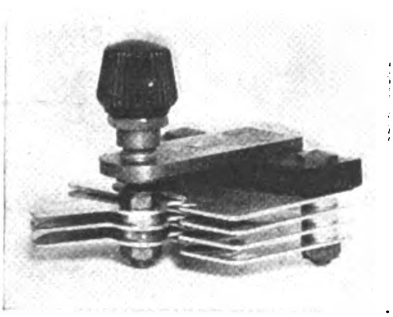
Kadel & Herbert

THE NEW 10-METER TRANSMITTER

This apparatus was developed by the Bureau of Standards for testing the short wavelengths that are now so popular.

WHAT'S NEW IN RADIO APPARATUS

This department is conducted by **Popular Radio Laboratory** *for the purpose of keeping the radio experimenter and the broadcast listener informed concerning the newest inventions and the approved developments in radio equipment. Only such apparatus as has been tested and endorsed by the Laboratory is noted in these columns.*



A seven-plate variable condenser.

A MIDGET VARIABLE CAPACITY

Name of instrument: Small variable condenser.

Description: The stator plates and also the rotor plates of this small variable condenser are mounted on a strip of hard rubber by means of two posts with suitable washers and nuts and with a shaft that is held by small brass arms and that contains a small knob at one end for revolving the plates. It is well constructed and an efficient piece of apparatus.

Usage: In a receiver in any place where a small variable capacity will be found useful.

Outstanding features: Compactness. Efficient. Easily adjustable. Neat in appearance.

Maker: Lombardi Radio Mfg. Co.

A NEW IMPEDANCE COUPLER

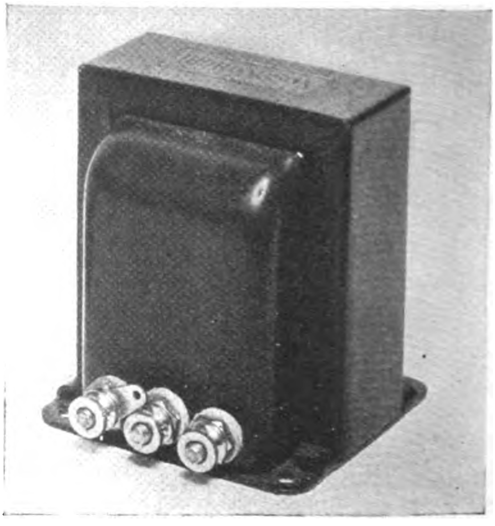
Name of instrument: Impedance-coupling coil.

Description: This instrument is really an audio transformer with part of the inductance to be connected in the plate circuit of a vacuum tube and the whole included in the circuit in series with a large fixed condenser as an impedance coupler in a distortionless audio-frequency amplifier. The coils are wound on a very large core which eliminates the possibility of saturation. It is equipped with three binding post terminals, to which are attached soldering lugs. The whole case is fitted with a metallic shield which may be grounded.

Usage: In a radio receiver as a coupling device at audio frequencies.

Outstanding features: High primary inductance. Truthful reproduction. Neat appearance. Adequate iron core.

Maker: Thordarson Electric Mfg. Co.



A highly efficient audio-frequency coupler.

A MODIFIED SOLENOID COIL

Name of instrument: Tuned-radio-frequency transformer.

Description: This coil is constructed in a manner that causes it to be self-supporting; it is practically a solenoid winding with a minimum of dielectric material in the electrostatic field between turns. It may be used wherever the ordinary tuned-radio-frequency coil has been used before and in a radio-frequency amplifier that is to be tuned with a variable condenser. It is equipped with soldering terminals for making connections to the other parts of the circuit.

Usage: In any receiver as an interstage-coupling device at radio frequencies.

Outstanding features: Low distributed capacity. Maximum inductance shape. High efficiency. Simple to connect in the circuit.

Maker: Benjamin Electric Mfg. Co.

A new type of battery meter.

A NOVEL BATTERY TESTER

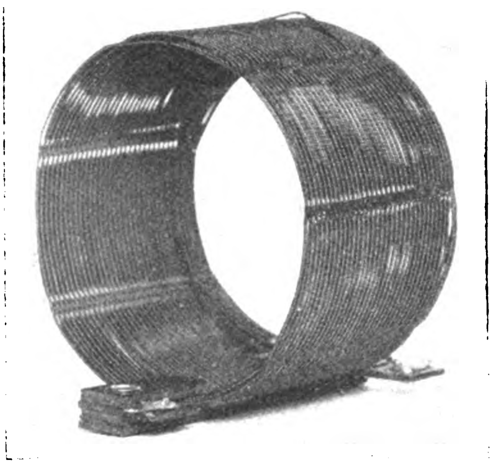
Name of instrument: Battery testing meter.

Description: This instrument, which may be used in connection with a storage battery, is termed the Cel-O-Meter. It contains two scales; the one at the left indicates the rate of charge or discharge of the storage battery; the scale at the right indicates the condition of the battery—showing whether it is fully charged, half charged or low. This determination is made by means of pressing a small button on the surface of the front panel. It is an accessory that will give the set owner an immediate indication of the condition of the storage battery.

Usage: In connection with a storage battery for determining its electrical condition.

Outstanding features: Compact. Quick reading. Sturdy in structure.

Maker: Cellokay Mfg. Corp.



A shielded inductance coil.

A TUBE REACTIVATOR

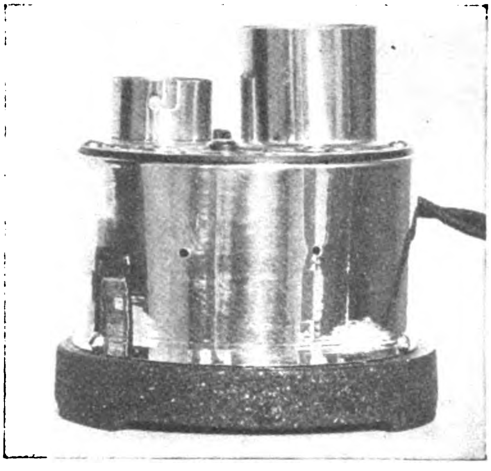
Name of instrument: A tube rejuvenator.

Description: This device contains a current converter for applying a series of currents to the filament circuits of thoriated filament tubes for renewing the filament emission of tubes that have been damaged or that are partially worn out. It is suitable for use with either the standard 201-a type or 199 type that operates from a thorium emission principle. It is equipped with two sockets for the two types of tubes and two sets of push buttons for applying the current.

Usage: In connection with thoriated filament vacuum tubes for restoring them to active use.

Outstanding features: Compact. Neat in appearance. Efficient.

Maker: J. Thomas Rhamstine.



An instrument that renews vacuum tubes.

WITH THE INVENTORS

CONDUCTED BY WILLIAM G. H. FINCH

THIS *department will keep you in touch with the latest inventions of interest on which patent rights have been granted, and which are significant contributions to radio art.*

Reduction or Elimination of Static

A METHOD and apparatus for reducing or eliminating static and other electrical disturbances in radio telephonic and telegraphic reception, is proposed by David G. McCaa of Lancaster, Pa., in his patent No. 1,522,136. It is claimed that with this invention the effects of static, atmospherics, strays and other natural or artificial disturbances, including other radio signals, are reduced on radio or other receiving systems, whereby the desired signals are readily distinguishable or become intelligible, notwithstanding the simultaneous existence of strong disturbing effects.

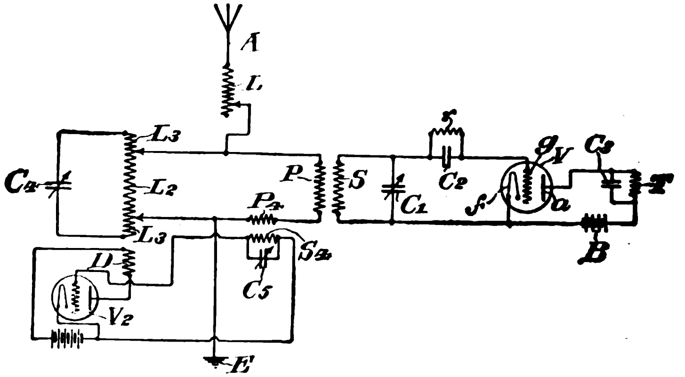
The system is shown in Figures 1 and 2. The received electrical energies representing both the desired signal and the disturbing effect are divided between reactive paths, one of which is employed for effecting the translation of the desired signals, and with another of which is associated means for impressing thereon a part of the energy of the desired signals which were previously amplified, to cause a change of reactance, which thereby withholds from the signal translating path the effect of the undesired oscillations to greater degree than the effects of the desired signal.

An Improved Vacuum Tube

IN patent No. 1,529,626, recently issued to Ernest Y. Robinson, of Manchester, England, means are disclosed whereby the electrodes or metallic members of a vacuum tube may form also part of the usual glass envelope.

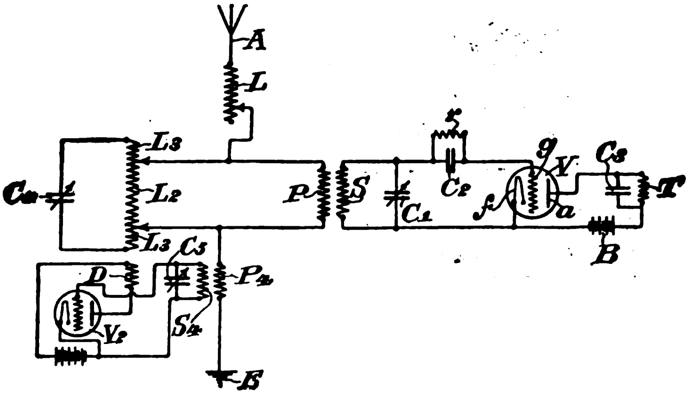
A Static Elimination System

JOSEPH SLIPIAN, of Swissvale, Pa., was granted patent No. 1,513,286, covering a system for static elimination which is quite novel and worthy. It is shown that the desired result may be obtained by including, in the receiving antenna, a resistor having such value as to effectively damp the receiving system. Non-resonant means are then associated with the



THE CIRCUIT DIAGRAM FOR THE McCAA ANTI-STATIC DEVICE

FIGURE 1: *This diagram gives theoretically the circuit plan for the device whereby static or artificial disturbances are reduced and the desired signals made more readily distinguishable and intelligible.*



ANOTHER VARIATION OF THE McCAA SYSTEM

Figure 2: *This schematic drawing shows another means for accomplishing static or interference reduction by means of a specialized circuit which decreases static but preserves the intensity of the signal itself.*

resistor, whereby the voltage-drop therein may be substantially neutralized for currents of predetermined frequency only.

For Reducing Interference

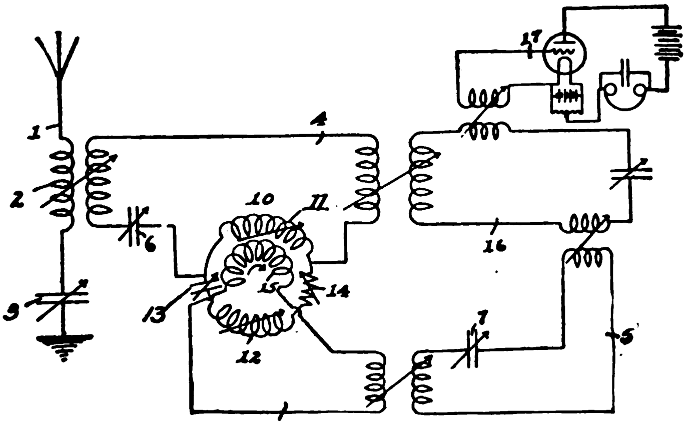
J. Weinberger, of New York, in his patent No. 1,525,526, also discloses a radio receiving circuit that is designed to reduce interference from other stations. This is accomplished by the use of intermediate tuned circuits and also a phase shifter designated as 10 in Figure 3.

Who Were Licensed Under Navy Owned Patents?

Some time ago the Navy Department announced that it would license manufacturers under various patents owned by the Navy Department. It is understood that a number of manufacturers made application for license to manufacture receivers embodying the inventions set forth in the Schloemilch & Von Bronk patent number 1,087,892. Popular Radio is curious to know who were the successful applicants. It will be appreciated if these applicants will identify themselves by communicating with Wm. G. H. Finch, care of Popular Radio and Wireless Age, 627 West 43d Street, New York.

A New Variable Resistance Grid-leak

George H. Humm of Fairfield, Conn., has been issued Letters Patent number 1,541,817 for a variable resistance grid-leak to be especially applicable for use in vacuum tube receiving circuits. This invention relates to a vari-



THE WEINBERGER ANTI-STATIC METHOD

Figure 3: *A diagram for the intermediate tuned circuit system which incorporates a phase shifter for static signal reduction.*

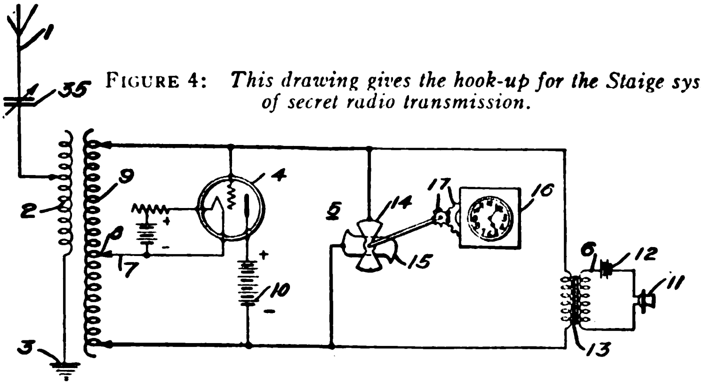


FIGURE 4: *This drawing gives the hook-up for the Staige system of secret radio transmission.*

able resistance, especially for use with radio apparatus, and particularly a variable resistance grid-leak for shunting the condenser between the vacuum tube and antenna in series with the grid of the tube. As is well known, a high resistance leak is necessary across the grid condenser to relieve the grid of the surplus of electrons of such polarity as would, if allowed to accumulate, choke the tube and cause distorted signals.

It is an object of the present invention to provide a variable resistance which will provide a given maximum and minimum resistance, and in which a continuous range of varying resistances may be provided between these points, so that the variation of voltage across the grid condenser, occasioned by the power, distances or other varying factors of different broadcasting stations, may be accurately compensated for, permitting a higher resistance to be placed in the circuit during the reception of weak signals, so that a minimum of energy is lost and a reduced resistance during the reception of reduced signals, to prevent distortion.

Further objects are to provide a device of this character which will be of simple and durable construction, convenient to install and manipulate, and will not deteriorate through use or age.

Secret Radiophone System

A SYSTEM of secret and selective radio transmission and reception that is applicable both to radiotelephony and telegraphy is disclosed in patent No. 1,528,032 issued to Stephen A. Staige, of Pittsburgh, Pa. He proposes that the carrier wave frequency be caused to vary through a predetermined cycle within certain limits. In order that the receiving station may receive messages sent by a system of the character designated, it is necessary that the timing of the receiving station shall pass through the same cycle, *i.e.*, wavelength of variation in frequency.

The transmitting circuit is shown in Figure 4 which is tuned by the variable condenser 5, which is provided with various shaped plates in order to produce any desired variation in the periodic change in frequency.

Figure 5 shows the receiving circuit in which 34 designates a variable condenser of similar construction and it will be noted that the variable tuning condensers in both circuits are geared to a clock motion. Any other suitable means may be employed to rotate said variable condenser so long as both are driven in synchronism.

The condensers may be rotated at any desired speed and an almost unlimited frequency or wavelength variation may be had.

It is evident that a transmitting station equipped with such a device would be intelligible at a receiving station only if said receiving station is equipped with a similar tuning device run at the same speed or in synchronism.

Other systems have been designed to accomplish the same purpose in which, however, no use is made of a moving device which must be kept in synchronism or speed at both the transmitter and receiver. Use is made of band filters in which certain frequencies are taken out at the transmitter and supplied at the receiver through local oscillators and filters.

It was thought some time ago that certain manufacturers possessing such systems would employ them to broadcast the highest grade of programs and only receivers supplied by them possessing the above features would be able to receive them, and by such methods they would be able to derive a direct revenue to support such programs.

A Variable Condenser

AN invention just patented by F. E. Stern and J. C. Randall of Hartford, Conn., patent number 1,537,561, relates to the type of condensers provided for radio communication sets that have a plurality of fixed plates and a plurality of plates interposed therewith and rotatively adjustable with relation thereto.

When the ordinary condensers of this character are in service and subject to the action of high frequency radio currents, the movement of a body toward or from the condenser changes the static conditions. For instance, after the condenser is adjusted to give the best results the removal of the hand from the knob used to turn the movable plates will alter the capacity of the condenser sufficiently to throw the apparatus out of tune. Furthermore, it is essential that the circuit connection with the movable plates be sure and positive under all conditions of service and wear, and that the movable plates be capable of easy movement when desired but that they be restrained from accidental movement after having been adjusted.

The object of the invention is to provide a simple, cheap and efficient means which can be used as a guide for locating the condenser on the panel on which it is to be mounted and which means can subsequently be employed in such manner as to eliminate the objectionable influence of the movement of the body toward or from the condenser; also to provide a tensioning means for the movable plates which will ensure a good and efficient contact under all conditions of expansion, contraction and wear.

These objects are attained by forming an independent metallic disc with the necessary openings to permit it to be applied to the front of the panel to which the condenser is to be fastened; in this way it may be used as a templet for ensuring the exact drilling of the hole for the operating spindle and also the holes for the attachment screws through the panel. The disc is afterwards located on the front of the condenser between it and the back of the panel, and is grounded so as to neutralize the effect of the application of the hand to or the removal of the hand from the operating knob. Further, it forms the tensioning spring (that bears on the rear end of the spindle which carries the movable plates) in such manner that there is a line contact between the parts which keep bright and clean even under the wear of long and constant service.

Induction Coil Mounting

Richard C. Rose of Osceola, Ark., was granted patent number 1,539,210. This invention has reference to inductance coil mountings especially designed for use in radio receiving systems. The primary object of the invention is to provide a device of this character wherein the mutual inductance between the primary and secondary circuits may be varied uniformly throughout the entire areas of the coil.

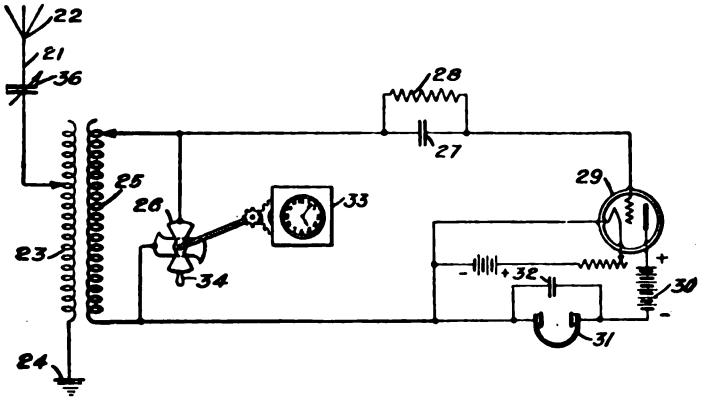
Another object of the invention is to provide a device of this character which may be used for either double or triple mounts for practically any conventional type of coils, and means are provided to permit of minute adjustment of the mutual inductive fields.

Another important object of the invention is to provide a coiled mounting constructed for the reception of coils of various sizes, thereby adapting the device for various usages.

Amplifying Apparatus

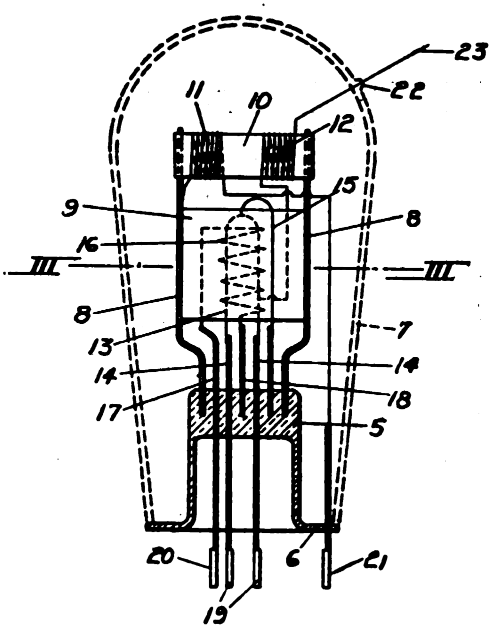
This invention discloses an electron discharge apparatus and circuits for amplifying and detecting high frequency signaling currents (radio telephony and telegraphy); it bears patent number 1,547,152, issued to Frank R. Elder of Schenectady, N. Y. One of the objects of the invention is to provide a circuit arrangement whereby the amount of amplification which may be obtained with a single device may be greatly increased.

It has been proposed in the past to employ a three-electrode electron discharge device for the simultaneous amplification of radio-frequency currents and audio-frequency currents. Another object of the invention is to provide a practical system whereby a four-electrode electron discharge device, particularly one of the negative resistance or pliodynatron type, may be employed for the simultaneous amplification of both radio and audio-frequency currents.



THE STAIGE SYSTEM FOR SECRET RECEPTION

Figure 5: *The electrical connections for a receiver which embodies the patented system of reception of signals which have been transmitted by the method explained in Figure 4.*



A COMBINATION TUBE AND RADIO FREQUENCY TRANSFORMER

FIGURE 6: *This gives an idea how McCullough has modified the standard vacuum tube assembly to accommodate radio frequency transformers within the envelope of the tube. It shows clearly the structure which permits shortening the leads in the plate circuit.*

A Unique Amplifying Apparatus

IN letters patent No. 1,547,154 issued to Albert W. Hull of Schenectady, N. Y., there is disclosed an electron discharge apparatus and circuits for amplifying and detecting high frequency signaling currents. Another feature of the invention is to provide a circuit arrangement whereby the amount of amplification which may be obtained with a single device may be greatly increased.

Similar results have been obtained in the past by reflexing *i.e.* using the same tube to perform two operations, that of radio and audio frequency amplification.

Mr. Hull obtains the above results in a new way. He does so by employing a pliodynatron or a tube with two grids, plate and filament.

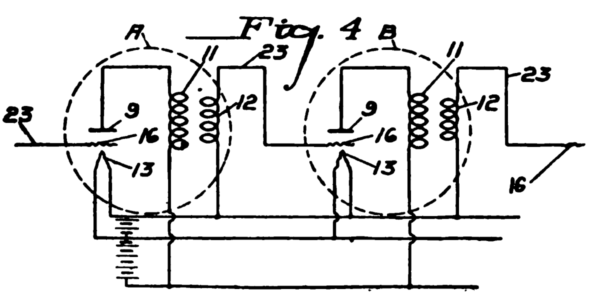
A Combination Tube and Transformer

MR. **FREDERICK S. MCCULLOUGH**, Wilkinsburgh, Pa., who is well known for his work with alternating current tubes, makes another contribution to the radio art. In patent No. 1,528,735, recently granted to him, he proposes to mount coils or radio frequency transformers within the envelope of the tube, thereby eliminating a number of external lead connections. This results in a material advantage in shortening of lead wires and in the consequent reduction of distortion due to the decreased impedance and capacity of such leads.

Furthermore, such construction enables apparatus involving the use of vacuum tubes to be very compact by reason of the saving of space gained by the elimination of such coils and lead wires.

In Figure 6 is shown the novel supporting means provided within the vacuum tube itself for mounting of coils or transformers within the tube, and an inspection of Figure 7 shows a wiring diagram illustrating a circuit employing this invention.

It is evident from both these drawings how such a construction eliminates long lead wires and results in the advantages as set forth in this patent.



THE WIRING DIAGRAM OF THE CIRCUIT THAT EMPLOYS THE McCULLOUGH INVENTION

FIGURE 7: *This diagram shows a standard radio frequency amplifier circuit in which the invention is employed. The wiring is considerably simplified by this arrangement.*

New and Useful Data About Coils

Do you know that many "low-loss" coils really have lower efficiency than some of the older types? See **POPULAR RADIO** next month—for December.

Engineering Library

NOV 20 1925

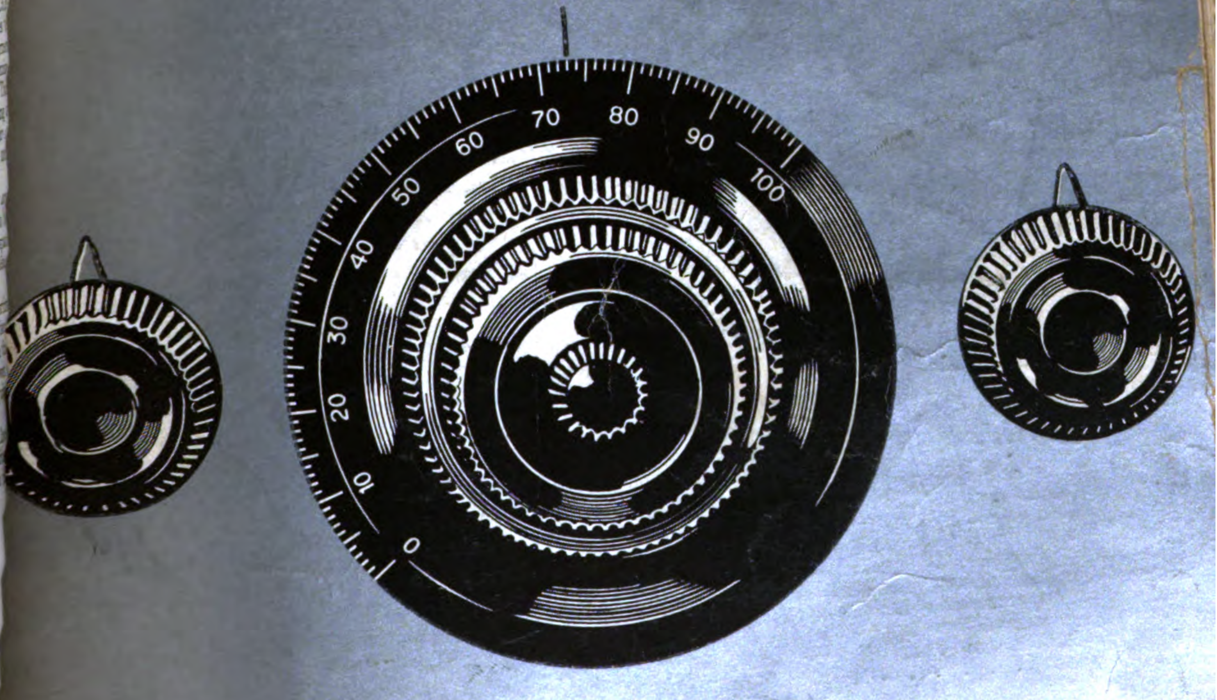
Popular Radio

with which is combined The Wireless Age

Edited by KENDALL BANNING

DECEMBER · 1925

25¢



—In this Issue—

HOW TO BUILD THE NEW LC-26 BROADCAST RECEIVER

Unchanging "B" power at last

RCA Duo-Rectron, Model AP-937, with Radiotron UX-874 and Rectron UX 213. . . $65

A Power Amplifier for Loudspeakers

May be connected to the first audio stage of any receiver, and to any loudspeaker—to supply a stage of power amplification for tremendous volume increase and marked improvement in tone. Operated from 60 cycle, 110 volt A. C. source RCA Uni-Rectron $105

RCA-
UNI-RECTRON
$105.

RCA has held its new power unit in the laboratories for more than a year after the main principles were developed. There were problems to overcome, and these the RCA Duo-Rectron solves at last.

FIRST—It supplies correct voltage for any size set up to ten tubes. A new vacuum tube—a *voltage regulator* had to be developed to take care of this. With the RCA Duo-Rectron you never get too much current on a small set, or too little current on a five, six or eight-tube receiver. It always supplies exactly the necessary voltage at any needed rate, up to fifty milliamperes.

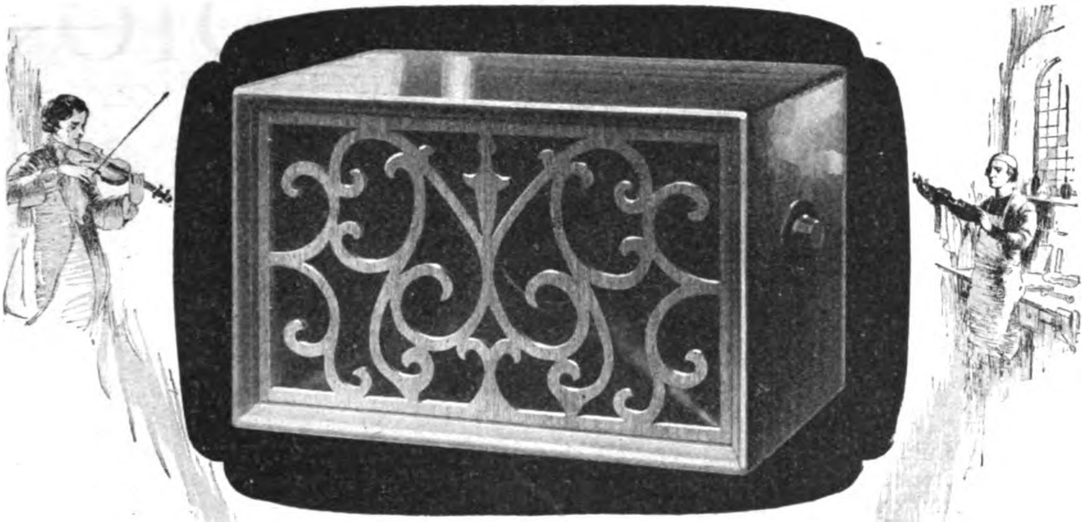
SECOND—The Duo-Rectron uses a new rectifying tube, specially developed to give *long life* under heavy usage.

THIRD—A newly designed filter system *takes out all the A. C. hum.*

Therefore, the RCA Duo-Rectron supplies the necessary plate voltages of 22½, 45, 90 and 135 volts for any existing type of radio receiver. Supplies it silently—dependably—unchangingly—from any 60 cycle, 110 volt A. C. lighting circuit. A unique feature of this unit is the furnishing of 135 volts on the plate for the operation of the new Radiotron audio-amplifiers UX-120 and UX-112.

RCA-DUO-RECTRON

RADIO CORPORATION OF AMERICA ~ NEW YORK ~ CHICAGO ~ SAN FRANCISCO



The Brandes Cabinet of mahogany, finished in walnut brown. The same unit, quality of tone and even greater volume than the Type H Speaker . . $30

Acoustics by Brandes

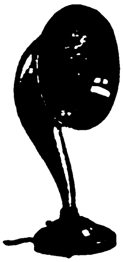
means better radio

LET the voice of your set be a Brandes. Let your set sing its best and speak its clearest—through a Brandes.

The new Brandes Speakers—perfected now after many busy years of experiment—give new clarified mellowness to the low tones, new rounded sweetness to the high.

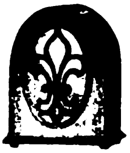
And there is a Brandes speaker to meet each person's requirements of appearance and price. A cone, a cabinet, a horn (Type H), a smaller horn, a phonograph attachment. All of Brandes quality.

Be sure your set is in its best voice—always—with acoustics by Brandes.



The Type H—a horn of graceful lines and antique green and black finish. Great in volume—true in tone. Adjustable . . $18.00

Prices slightly more west of the Rockies and in Canada.



The Brandes Cone—a truly decorative bit of furniture that conceals a remarkable speaker . . . $38

Send for an interesting booklet describing Acoustics by Brandes.

Brandes Products
Corporation
200 Mt. Pleasant Avenue
Newark, N. J.

Brandes

EXPERTS IN RADIO ACOUSTICS SINCE 1908

© Copyrighted by Brandes Products Corp., 1925

POPULAR RADIO

WITH WHICH IS COMBINED "THE WIRELESS AGE"

EDITED *by* KENDALL BANNING

FOUNDED 1911

CONTENTS *for* DECEMBER, 1925

(*Cover design by Frank B. Masters*)

VOLUME VIII NUMBER 6

The King Issues His First Radio Commands to the Air Fleet.......FRONTISPIECE
How to Build the New LC-26 Receiver........*Laurence M. Cockaday*..*Page* 495
Where Fortunes Wait.. 512
How to Improve Broadcast Reception..........*John V. L. Hogan*.......... 513
VIII: How to Increase Operating Distance
Chalk Talks in Radio—No. 3................*J. W. Goosetree*............ 519
No. 3: What "Current" Means
What Every Radio Experimenter Should Know About Condensers.......................*Sylvan Harris*.............. 521
The Oboe in 4-D..........................*Thomas L. Bayard*......... 526
"Truthful Reproduction;" How to Get It from Your Set..............................*Paul Godley*............... 533
A New Method of Transmitting Pictures by Telephone—or Radio..................*Edmund H. Hansen*......... 540
"What Set Shall I Buy?"...................*The Technical Staff*......... 545
A Novel and Practical Use of Radio on Freight Engines...........................*Austin C. Lescarboura*....... 551
Radio that Runs on a Beam 551

DEPARTMENTS

In the Experimenter's Laboratory:

A Vacuum Tube as a Voltmeter.................*S. Gordon Taylor*............ 552
How to Drill Large Holes in Panels............*Robert W. Tait*.............. 555
A Shunt Plate Feed for Loudspeakers...........*Laurence M. Cockaday*......... 557
The Relative Merit of Some Types of Inductance..*Byron B. Minnium*............ 560
What Readers Ask..........................*Hugh S. Knowles*.......... 562
What's New in Radio Apparatus.............*The Technical Staff*......... 566
In the World's Laboratories.................*E. E. Free*................ 572
Broadcasts.................................*J. Andrew White*........... 582
The Broadcast Listener.....................*Raymond Francis Yates*..... 587

VOLUME VIII DECEMBER, 1925 NUMBER 6

Published monthly by Popular Radio, Inc., 627 West 43rd St., New York, N. Y., telephone number, Chickering 1906; Douglas H. Cooke, President and Treasurer; Kendall Banning, Vice-President; Laurence M. Cockaday, Secretary; Joseph T. Cooney, Asst. Treasurer. Price 25 cents a copy; subscription $3.00 a year in the U. S., Canada and all countries within the domestic postal zone; elsewhere $3.50 a year, payable in advance. The International News Company, Ltd., No. 5 Bream's Bldg., London, E. C. 4, sole distributors in England. Entered as second class matter April 7, 1922, at the Post Office at New York, N. Y., under the act of March 3, 1879.

Copyright, 1925, and title registered as a trade-mark by Popular Radio, Inc. Copyright in Great Britain by Popular Radio, Inc., 6 Henrietta St., Covent Garden, W. C., London, England.

Printed in U. S. A.

LAURENCE M. COCKADAY, *Technical Editor*

E. E. FREE, Ph.D., *Contributing Editor* JOHN V. L. HOGAN, *Contributing Editor*

For advertising rates address

E. R. CROWE & COMPANY, INC.

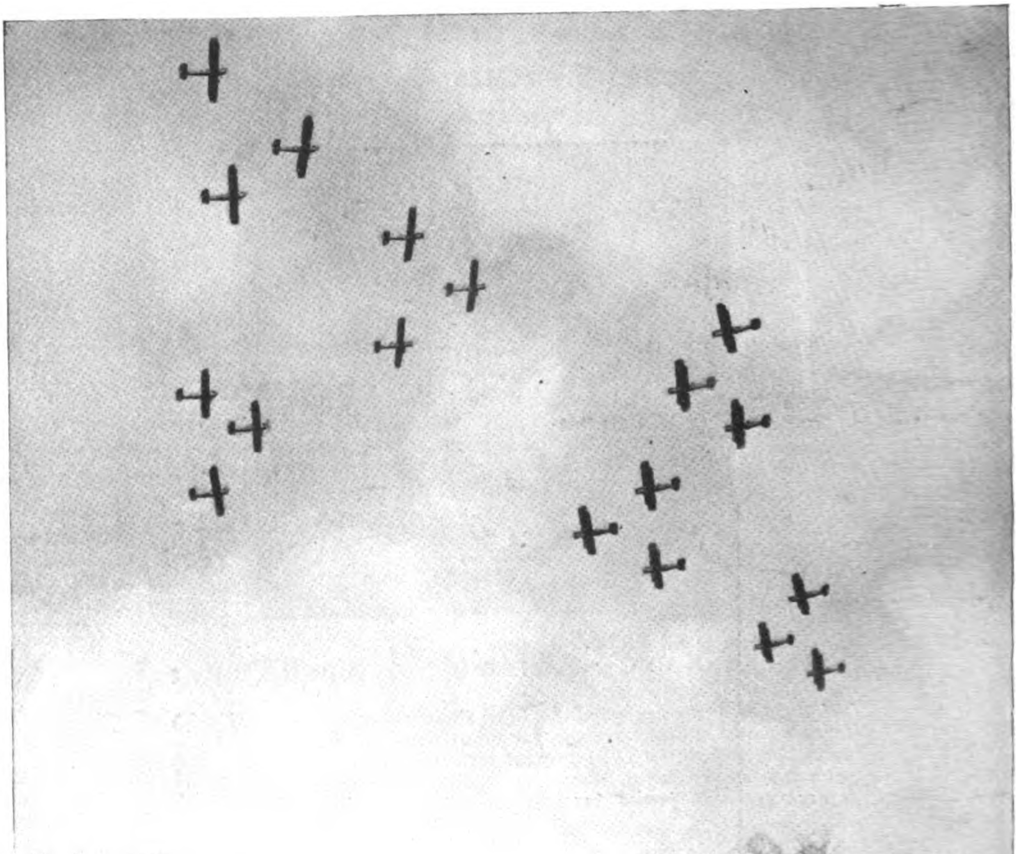
New York: 25 Vanderbilt Avenue Chicago: 225 North Michigan Avenue

POPULAR RADIO'S Admirable Accomplishment

"IT *has been my good fortune to be closely connected with teaching and writing science for some years, and I know, therefore, how difficult it is to present technical subjects in interesting yet authoritative ways.* POPULAR RADIO *is doing this admirably; it deserves high praise for this accomplishment.*"

David Grimes

DAVID GRIMES, INC.



Keystone View Co., London

The King Issues His First Radio Commands to the Air Fleet

Seated before the microphone, King George V directed for a few moments the movements of the airplanes that flew in military formation as part of the program of the Aerial Pageant recently held at Hendon, England.

Popular Radio

WITH WHICH IS COMBINED "THE WIRELESS AGE"

VOLUME VIII DECEMBER, 1925 NUMBER 6

HOW TO BUILD THE NEW

LC-26 RECEIVER

COST OF PARTS: *About $63.50*

RECEIVING RANGE: *New York to Los Angeles (2,700 miles) in experimental tests, but maximum range not yet determined*

This new receiver is the latest and most valuable contribution that has yet been made by the POPULAR RADIO LABORATORY to the radio art. It has been in course of development for nine months. In its present form, as described in this article, it is recommended as the most efficient receiving set that has ever been placed at the disposal of the radio experimenter. And it may be built at home at a cost for parts that brings it within the means of the average pocketbook.

—EDITOR

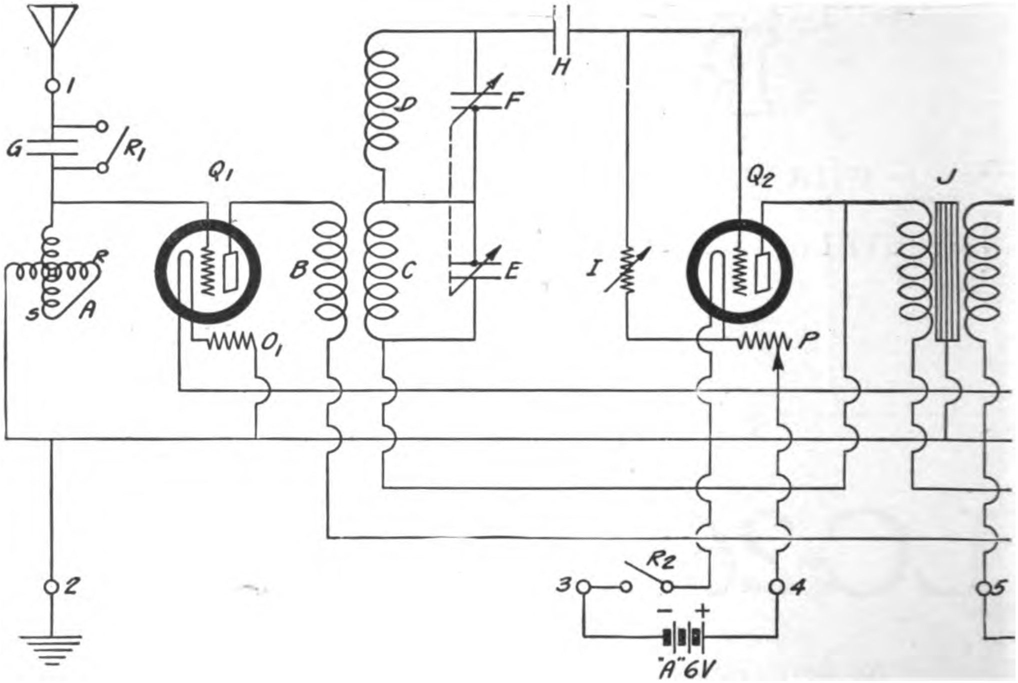
By LAURENCE M. COCKADAY

WHEN preparing a design for a popular receiver for the home-builder of radio sets, the most important item for consideration is the quality of reproduction.

Ask the ordinary layman what he considers the most important factor in a receiving set and he will almost always reply, "Clarity of reproduction of speech and music."

Ask the radio experimenter this same question and he will tell you that quality reproduction can be obtained only by using some form of non-distorting amplification, such as impedance or resistance-coupling, and a really good loud-speaker such as one of the cone type speakers.

Ask the same question of the trained engineer and he will answer carefully. He will tell you that truthful reproduction from a receiver depends upon a number



of obscure phenomena in both receiver and reproducer operation. We may study and analyze these considerations in the order in which they appear.

1. *Amount of radio-frequency amplification.* This is important in the reception of local signals, for if the radio-frequency amplification is too great on a signal of great intensity, the detector tube will not function properly as a rectifier and distortion will be introduced to the audio-frequency amplifier with consequent poor reproduction:

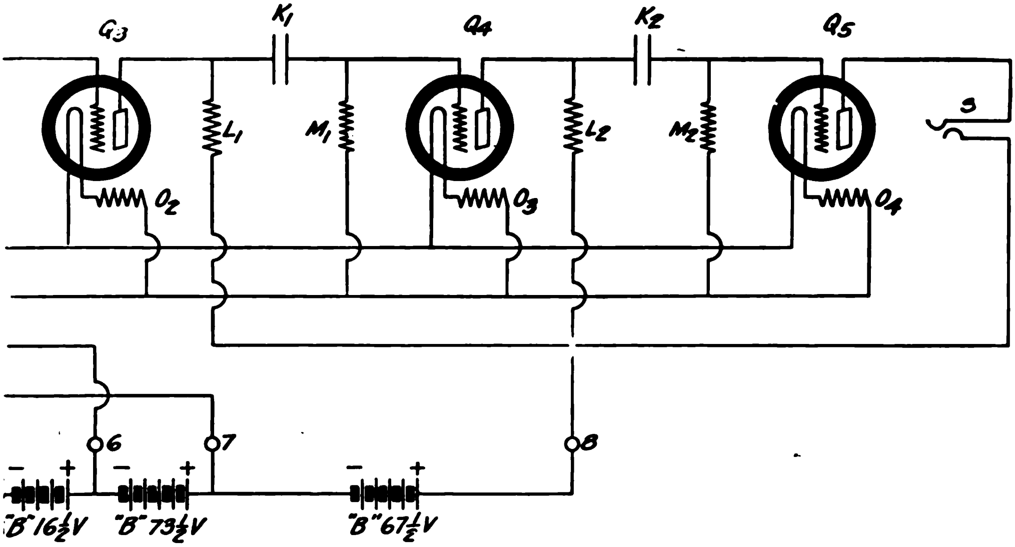
2. *Straight-line audio-frequency amplification.* The second characteristic which must be incorporated into a receiver is the ability of the audio-frequency amplifier to amplify or strengthen signals of all frequencies by approximately the same amount. In other words, a signal of 75 or 100 cycles should be amplified by the same amount as a signal of 1,000 cycles or so. This is one of the most common forms of trouble in the ordinary receiving set. High tones and tones of medium pitch are usually amplified to somewhere near the same intensity, but the ordinary transformer design in the past has neglected to a large extent the signals below 150 cycles. This dropping out of the lower frequencies from speech and music heretofore received and amplified by the common receivers has resulted in a thin and screechy tone which is not natural. An amplifier should therefore bring out the low-frequency characteristics.

3. *Adequate output power.* An amplifier of straight-line-frequency characteristics when used with a sensitive receiver must have an amplifying tube in the last stage of large enough capacity so that it will be able to furnish the power necessary for reproducing the low tones which are received. This is also one of the garden-variety of faults which is found in receivers today. To reproduce a low tone (below 150 cycles) there is required thousands of times as much energy applied to the ear as necessary to reproduce high tones of 2,000 or 3,000 cycles to the same intensity. A larger tube must be used in the output stage.

4. *Proper biasing of the grids through-*

THE COMPLETE CIRCUIT DIAGRAM

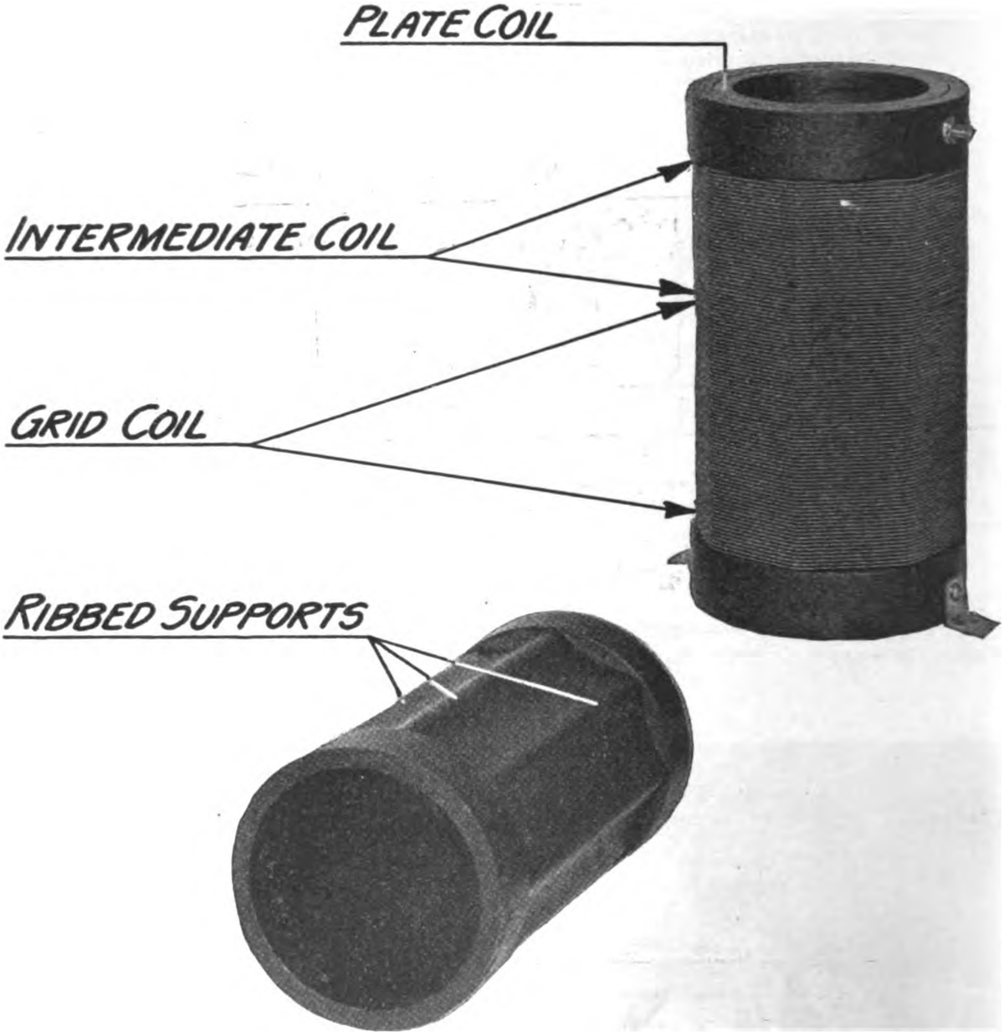
Figure 1: *This is the hook-up for the new LC-26 Broadcast Receiver. Notice that all of the symbols for the instruments bear designating letters which reappear in the list of parts and throughout the text and the following illustrations; this eliminates the possibility of mistakes in construction and wiring up.*



From a photograph made for Popular Radio

NINE MONTHS OF RESEARCH WERE SPENT IN DEVELOPING THIS RECEIVER

Figure 2: *In this picture, the author is shown with one of his assistants at his experimental work in the laboratory. This development work lasted over a period of more than nine months before the final circuit design was completed and a receiver produced combining such great radio-frequency amplification with really lifelike tone reproduction.*

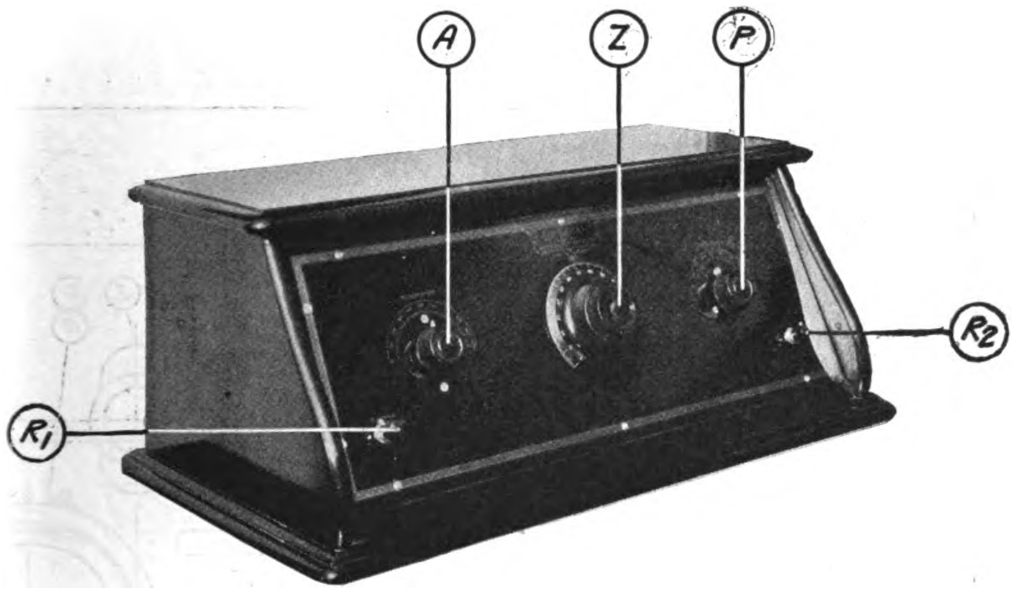


THE NEW TYPE OF INDUCTANCE USED IN THE SET

FIGURE 3: *In this type of winding, known as Octaform, the wires touch the insulating support only on the ridges which constitute but a small percentage of the total periphery area. This reduces the distributed capacity and the losses to such an extent that the efficiency of the coil is greatly increased over that of an ordinary solenoid.*

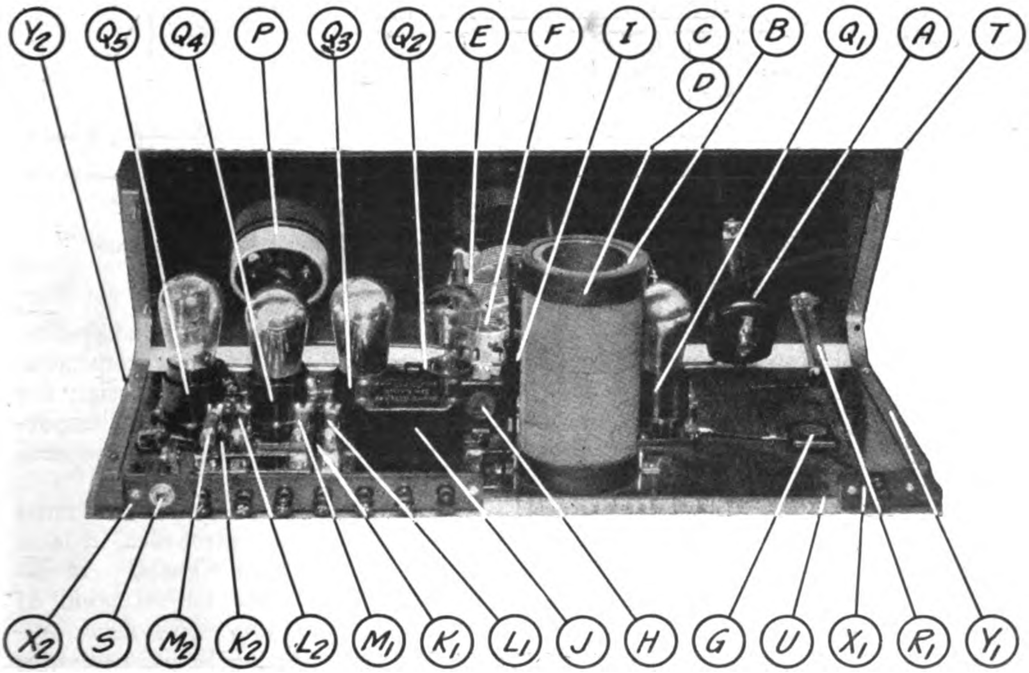
out the receiver. Especially in transformer amplifiers, the matter of grid bias is extremely important, and exceptionally so on the last stage. This is true also from an economy point of view. In the resistance-coupled type of amplification this fault is not so evident as a biasing effect may be easily obtained by means of the grid-leaks and coupling condensers which are necessary to this form of amplification.

5. *Proper transformer design.* For a non-distorting receiver, it is extremely important that transformers are designed for the proper stage where they are to be used and for the type of tubes that they are to be used in connection with. Some of the most important considerations here are the input impedance, secondary distributed capacity and the ability of the iron core to withstand saturation with maximum plate current that it will be



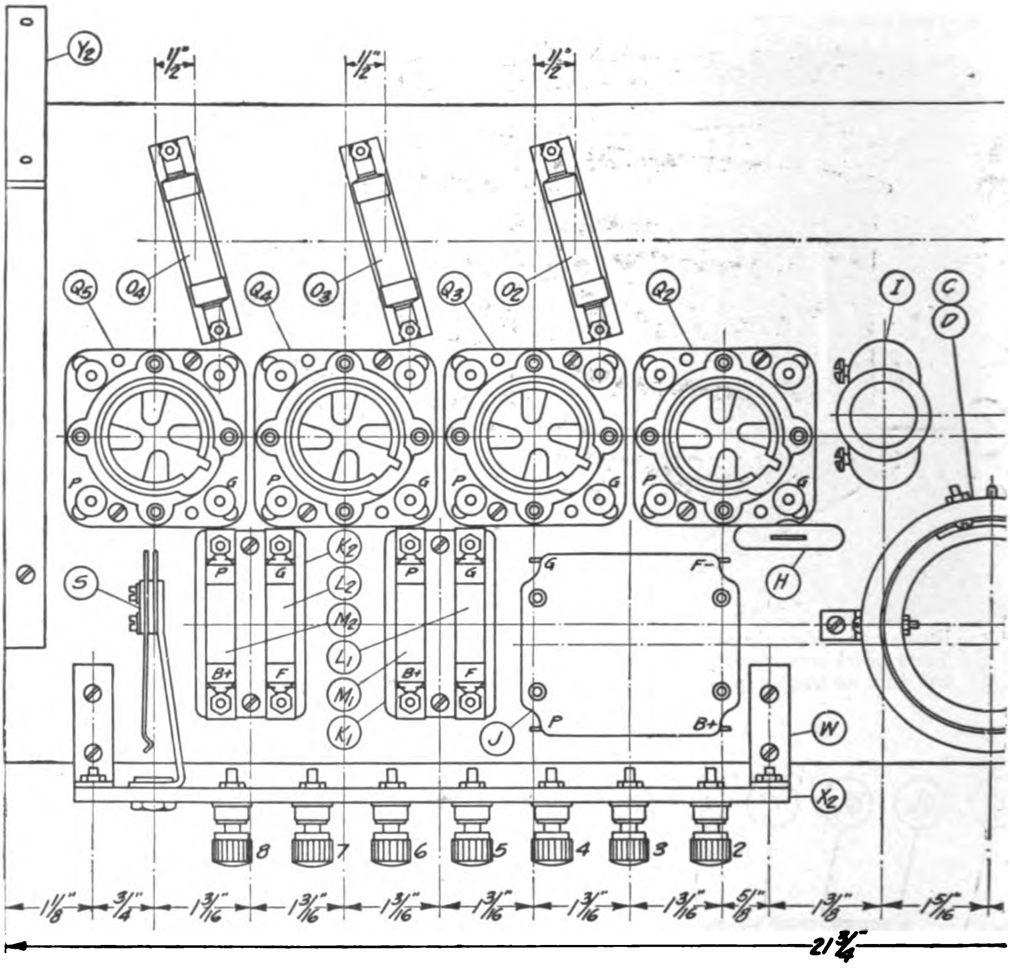
THE FRONT VIEW OF THE NEW RECEIVER

FIGURE 4: *How the set looks from the front. As the dials and knobs are marked with letters which correspond to the instruments to which they are attached, the prospective operator will have no trouble in locating the various tuning controls as they are explained in the instructions for tuning.*



VIEW OF THE SET FROM THE REAR

FIGURE 5: *This picture shows the general arrangement of all the instruments fastened to the panel or base. The exact locations for the instruments are shown in Figure 6.*



THE WORKING DRAWING FOR CONSTRUCTION

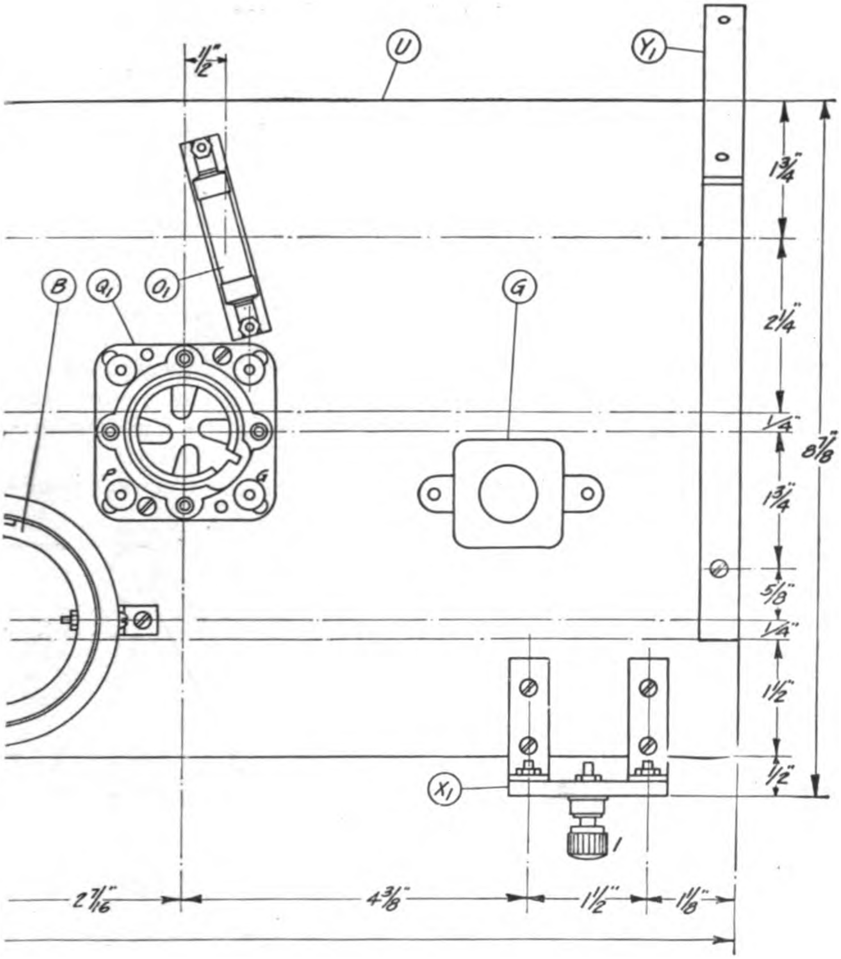
Figure 6: *Here are shown the correct positions for the instruments which are mounted on the baseboard. The positions are given center to center, for all instruments.*

subjected to. These considerations are important alike in reproducing low tones with fidelity, and in preventing resonance at high frequencies, which is sometimes liable to produce howling.

6. *Non-distorting loudspeakers.* Another very important consideration is, of course, in the loudspeaker that is to be used for converting the amplified electric energy into sound waves. The device should have the capacity to start in motion a sound wave of low frequency with the same ease that it can propagate a high frequency tone. This, of course, is best realized at the present time by using a large cone-type loudspeaker.

Of course, there are other considerations that enter into an ideal design for a receiving set. Two of the most important of these are (a) simplicity of operation and (b) selectivity.

A receiver to be really popular must approach the single control idea, at least for reception of local signals. An allowance may be made for reception of distant signals in that some slight adjustments are usually found necessary to bring up distant reception to the required intensity for enjoyable reproduction.



The selectivity of the receiver is also extremely important in that it enables the operator to tune in the station he wants without also tuning in the station he does not want.

Then, lastly, we come to another consideration which really is important to a certain group of radio users and that is the matter of radio-frequency amplification —sensitivity. A receiver should be able to amplify at radio frequencies with a ratio large enough to enable the reception of distant signals under any conditions of location. This is important in a large number of cases where people are not situated in a favorable location for radio reception.

During the last ten months the design work on a receiver that incorporates the considerations mentioned above has been in steady progress; this article is written for the express purpose of telling the experimenter and radio fan "how to build the new LC-26 broadcast receiver" that incorporates the principles as outlined.

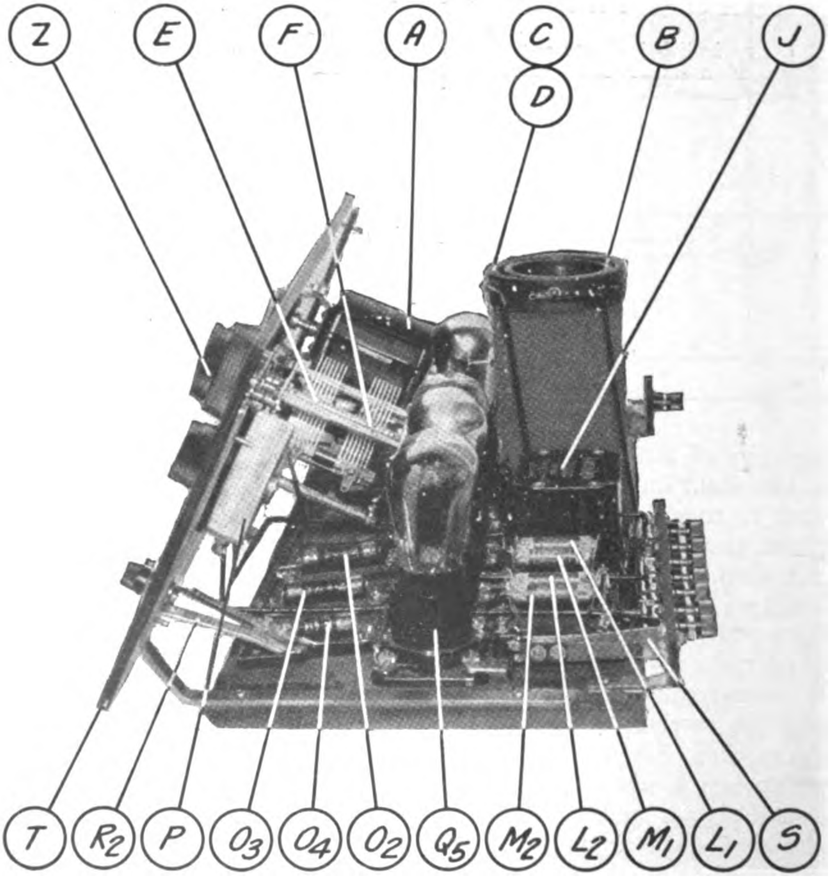
The receiver is, in essence, a single-control receiver that incorporates one stage of radio-frequency amplification, which cannot oscillate and which cannot radiate.

This type of radio-frequency amplification may be used on any antenna from 10 to 200 feet in length with reliable and satisfactory results.

The receiver incorporates a modification of the four-circuit principle as applied to the detector circuit, which gives maximum regeneration control over the whole wavelength range, that is independent of frequency. A new type of coil form known (See Figure 3) as "Octaform" has been used to obtain the highest efficiency in the tuning circuits. This assures not only extremely high radio-frequency amplification but simplified control. It reduces the number of tuning controls over those used with other popular single-stage radio-frequency amplifiers used in connection with a regenerative detector, and this in itself is of course a large advantage.

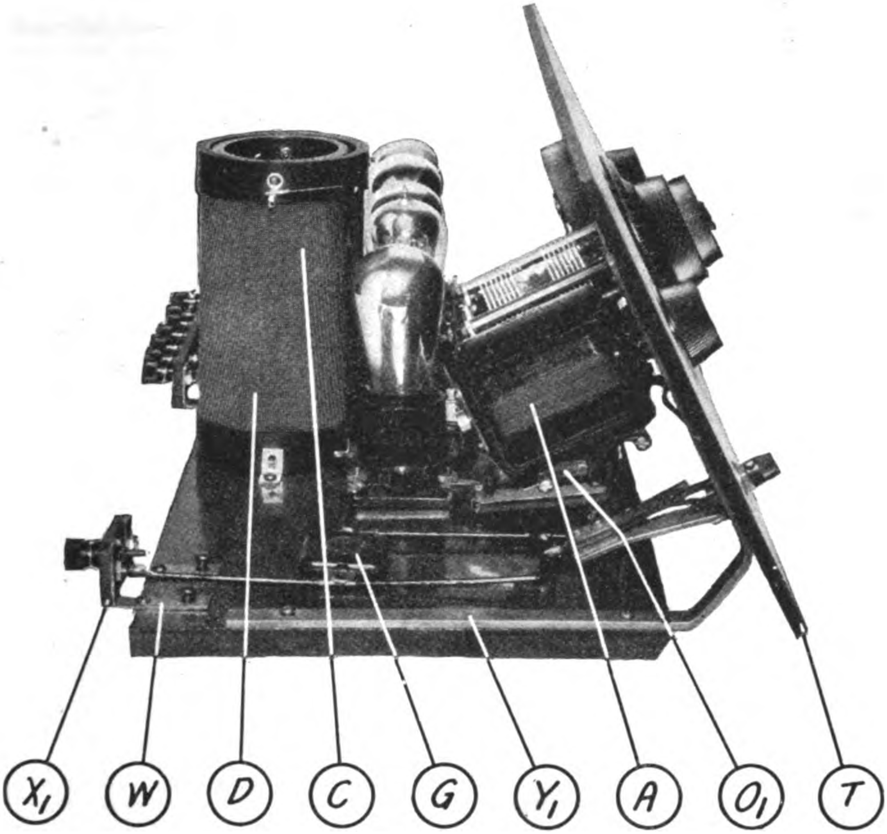
The receiver also incorporates one stage of transformer-coupled amplification with a transformer that is capable of reproducing lower frequencies. This follows the detector circuit so that there is no chance of saturation of the core of the transformer on account of the extremely low plate current that is used in the plate circuit of the detector. Then, follow two stages of resistance-coupled amplification with larger grid condensers, for improving the straight-line-frequency characteristics of these amplifiers over what have been formerly used. And then in the last stage is incorporated a tube of increased output power for handling satisfactorily the low tone energy produced by the receiver.

The "LC-26 broadcast receiver" is de-



VIEW OF THE RECEIVER AS SEEN FROM THE RIGHT

FIGURE 7: *This end view shows the manner in which the panel is held in position by the large brass brackets and the general scheme of mounting the sockets, the resistances and the jack.*



VIEW OF THE RECEIVER AS SEEN FROM THE LEFT

Figure 8: *This illustration shows the general manner of mounting the variometer, the coil set, the panel switches, the tube sockets and the small connecting blocks.*

signed to operate at its best when used with a cone-type loudspeaker.

The schematic wiring diagram is shown in Figure 1.

Parts Used in Building the Set

In all the diagrams in this article each part bears a designating letter; in this way, the prospective builder of a set may easily determine how to mount the instruments in the correct places and connect them properly in the electric circuit.

The same designating letters are used in the text and in the list of parts at the end of the article. (See page 511.)

¶ *The list of parts there given includes the exact instruments used in the set from which these specifications were made up. The experienced amateur, however, will be able to pick out other reliable makes of instruments which may be used with equally good results. But we recommend that the novice follow the list, as the diagrams in this article will tell him exactly where to bore the holes and exactly where to place the connections.*

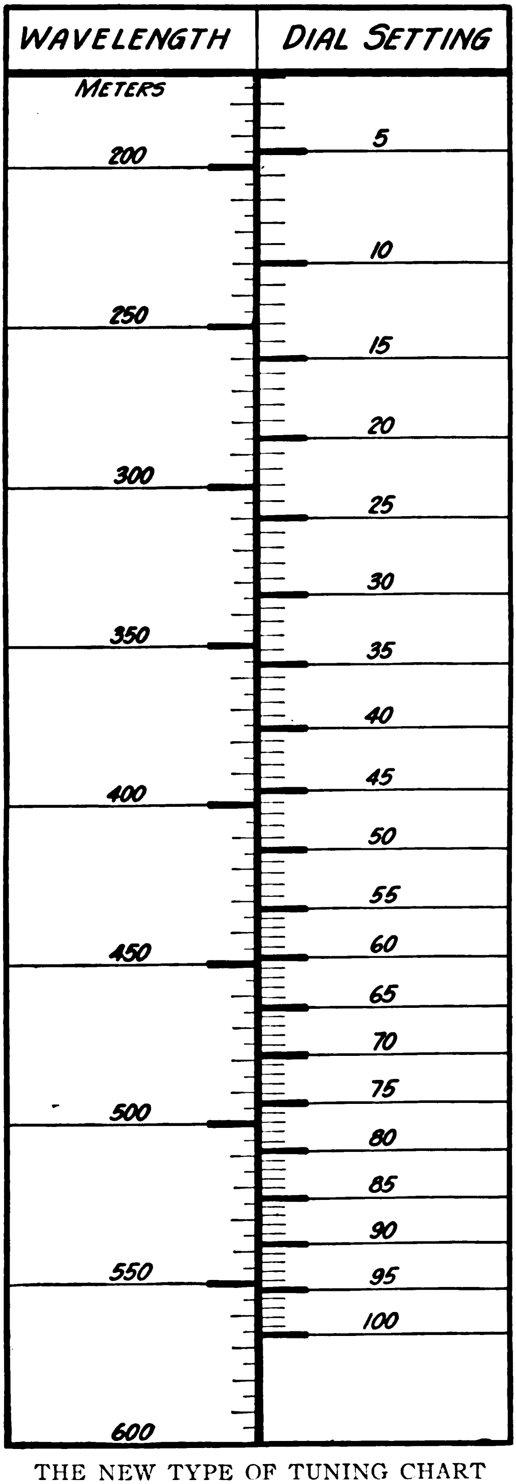
If instruments other than the ones listed are used, the only change that will be necessary will be the use of different spacings for the holes that are to be drilled in the panel for mounting the instruments.

How to Construct the Set

After procuring all the instruments and materials for building the set, the amateur should prepare the panel T. (Shown in Figures 5, 6, 7 and 8.)

First of all, cut the panel to the correct size, 8 by 22 inches. Then square up the edges smoothly with a file. The centers for boring the holes (which are necessary for mounting the instruments) should be laid out on the panel as shown in Figure 9. A convenient method for doing this is to lay out all center holes on a piece of paper the same size as the panel; then the piece of paper may be fastened on the panel and the centers marked directly on the panel by punching through the paper with a sharp, pointed instrument.

If all the holes to be drilled are first started



THE NEW TYPE OF TUNING CHART

FIGURE 13: *A new chart that shows you exactly how to tune the LC-26 receiver for any given wavelength.*

with a small drill, one-sixteenth inch in diameter or less, they can be more nearly centered.

The holes outlined with a double circle should be countersunk, so that the flat-head machine screws used for fastening the instruments are flush with the panel. All the rest of the holes in the panel are straight drill-holes. Sizes for the diameters of these holes have not been given, but the builder will readily decide what size hole is necessary by measuring the diameter of the screws and shafts of the instruments that must go through the holes.

When the panel is drilled, the builder may give it a dull finish by rubbing the face of the panel lengthwise with fine sandpaper until it is smooth. This process should be repeated, except that light machine oil should be applied during the second rubbing. Then rub the panel dry with a piece of cheesecloth. A permanent dull finish will be the result. Or, the panel may be left with its original shiny-black finish, if care has been exercised, so that it has not been scratched during the drilling.

After the panel has been prepared the experimenter is ready to mount the instruments on it.

If the specified drilled and engraved panel is bought, of course, this work will be unnecessary, as the drilling and finishing are already done by the manufacturer of the panel. The panel in this case is a very beautiful piece of apparatus, as it is decorated with a beautiful border design in gold and the dial positions are marked with inscriptions.

First of all, mount the variometer A on the left-hand end of the panel by means of two screws and nuts inserted through the panel. See Figure 5.

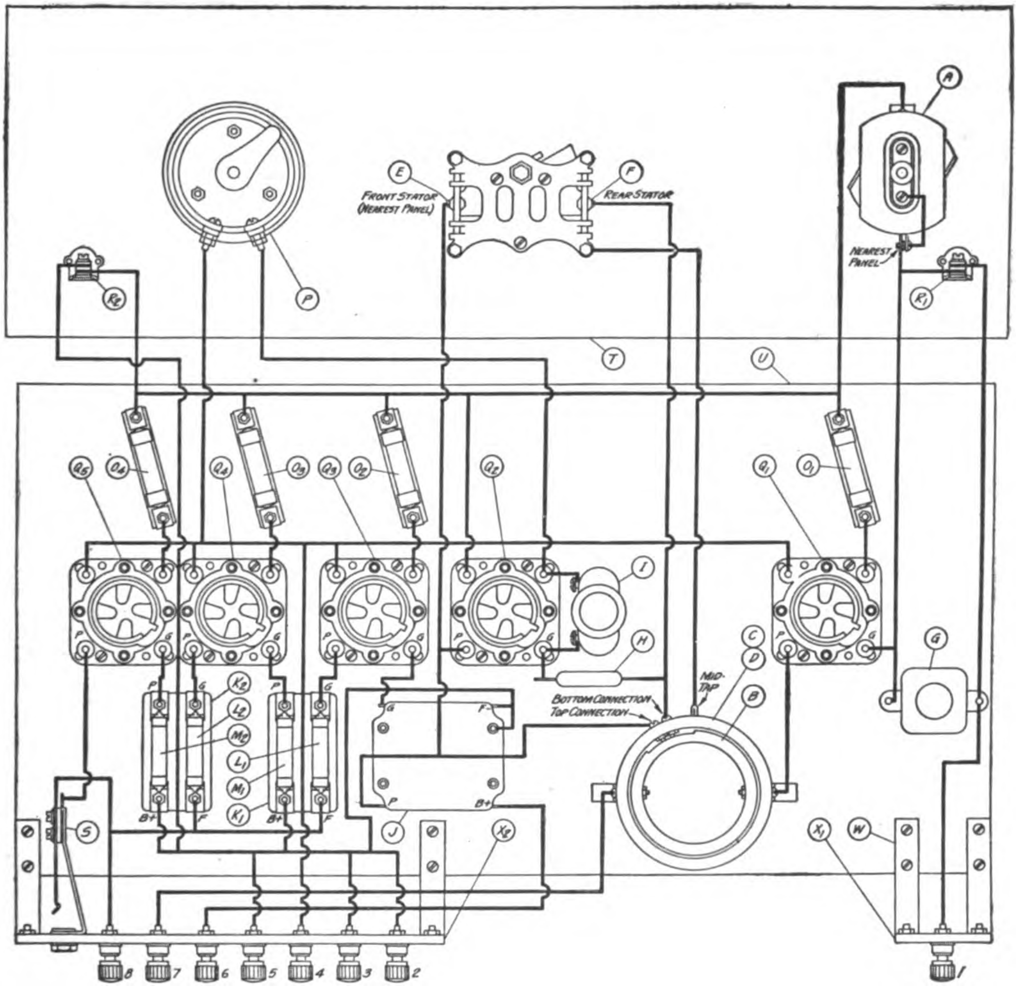
Then, attach small knob to the variometer on the front of the panel by means of the set screw. The knob should be adjusted in the proper position with the rotor turn in a vertical position in the same manner as the stator with the front rotor lead wire pointing to the left when looking at the back of the panel and the rear rotor lead wire pointing to the right. For this position of the rotor, the pointer on the small knob should be horizontally to the left when looking at the front of the panel. This will be the position for smallest inductance.

Next, mount the double variable condenser, E and F, on the panel so that the rotor plates will swing upward when they are not in meshed position. (Shown in Figures 5, 7 and 8.) Then attach the dial Z by tightening the set screw on the shaft. Be sure that the three screws that mount the condenser EF are countersunk slightly below the surface of the panel so that they do not interfere with the felt on the dial.

When this is finished fasten the rheostat P to the panel by means of three screws as shown in Figures 4, 5 and 7 and attach the small knob on the front of the panel.

Next mount the two jack switches R1 and R2 on the panel as shown in Figures 4, 5, 7 and 8.

This completes the construction work on the panel and you are ready to mount the instruments on the baseboard. The baseboard is supplied with the cabinet, and it should be taken



THE PICTURE DIAGRAM FOR CONNECTING UP THE VARIOUS INSTRUMENTS

Figure 9: *The upper rectangle represents the panel and on it the instruments are drawn just as they appear. The lower rectangle represents the baseboard and the instruments are drawn in about their relative positions. The wires drawn in heavy black lines show the exact way to run the wires to connect the instruments and parts after you have mounted them according to the instructions given.*

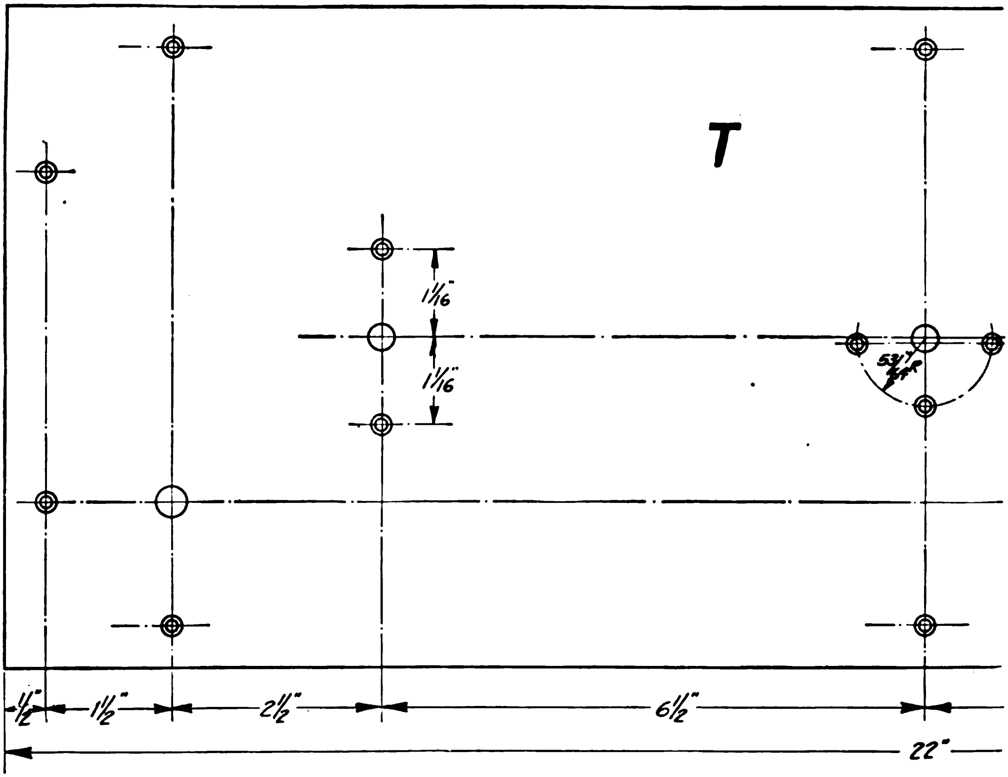
out and the instruments mounted on it as shown in Figure 6, which is the working drawing for construction.

First mount the five sockets, Q1, Q2, Q3, Q4 and Q5 in their respective places as shown in Figures 5, 6, 7 and 8.

Next attach the four amperites O1, O2, O3 and O4 in their respective positions as shown clearly in Figure 6. All of these instruments are to be screwed directly to the baseboard. Next fasten down the two resisto-couplers K1 and K2 as shown in Figure 6. Be sure that these are turned so that the terminals marked P and G face the tube sockets in such a position that the P terminal on the resisto-couplers faces the grid terminal on the sockets and the G terminals on the resisto-couplers face the plate terminals. This is the reverse of the way the resisto-couplers are ordinarily used as they are usually inserted between the sockets but in this position they take up too much room.

Next mount the coil-set B, C and D in proper position as shown in Figures 5, 6, 7 and 8 with the terminals pointing toward the front of the set. The coil may be fastened down by means of two screws inserted through the small brass brackets at the bottom of the coil.

Then, mount the audio-frequency transformer J in place as shown in Figures 5, 6 and 7. Be sure that the terminals are pointing in the



THE DRILLING PLAN FOR THE PANEL

Figure 10: *This drawing shows where to drill the holes for mounting the instruments. The correct spacings are given for the holes. The holes outlined with a double circle should be countersunk. Always start drilling holes in the panel with a small drill—one-sixteenth is a desirable size.*

direction indicated in Figure 6.

When this is done the work on the sub-panel may be left for a while and the two connection blocks X1 and X2, the dimensions of which are shown in Figure 14, should be prepared and the binding posts attached. The small brass brackets may then also be screwed tight to the block and the jack S mounted on the larger block X2.

Now fasten down the two blocks, X1 and X2, on the sub-base U by means of four screws inserted through the brass brackets into the baseboard.

Then, prepare the two large brass brackets, Y1 and Y2, which are to be used for attaching the main panel T to the base U at the proper angle; the dimensions for these angles including the drilling and bending are also shown in Figure 14. Be sure that you have the angles made with the correct drilling holes and bends so that the panel will fit evenly. Then mount the panel in position on the brackets. This had best be done by slipping the baseboard U in position in the cabinet with the brackets Y1 and Y2 attached and then fastening the panel in position with four screws. You are now ready to start on the wiring as the construction work is completed.

How to Wire the Set

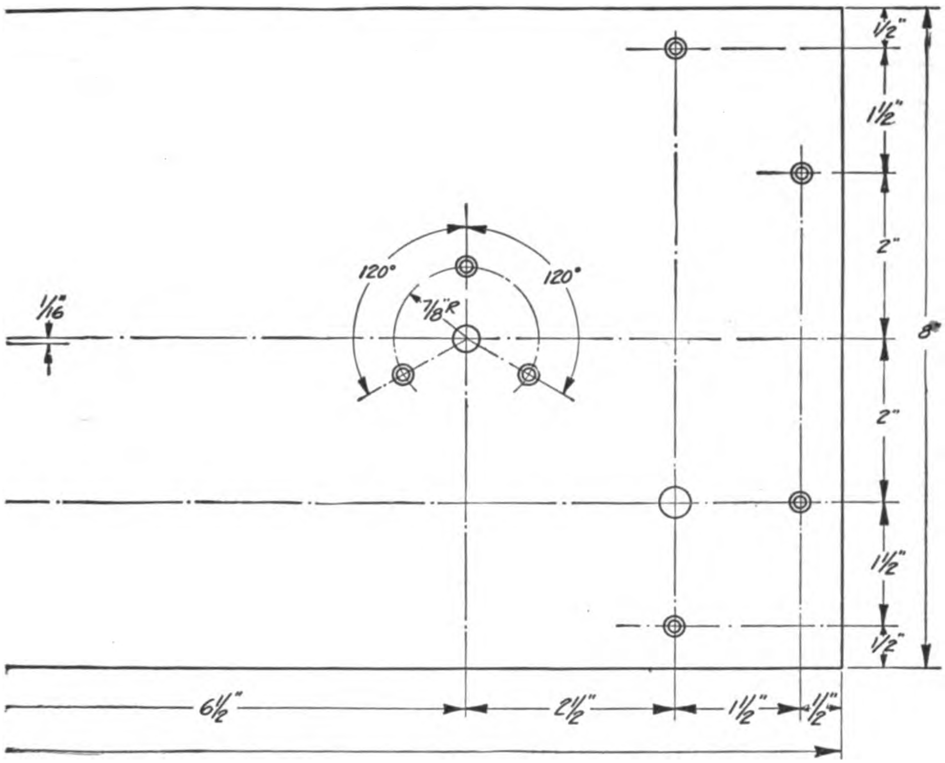
The design of this set is such that the wiring of the grid circuit of each of the five tubes is made extremely short and is isolated from other parts of the circuit. In fact, this idea has been employed throughout and the leads are so arranged that the shortest connections may be used. As this is the case, the set should be wired with bus-bar.

Either a tinned-copper, round bus wire or an insulated round bus wire such as "Celatsite" may be used for the connection. All connections should first be shaped so that they will fit. They should then be soldered in place. Refer to the wiring diagram in Figure 1 and more specifically to the picture diagram in Figure 9 for the exact way in which to run the wires.

Start wiring up by running a connection from binding post No. 1 to the right-hand side* of the antenna series condenser G and continue

---

*The front connection on any instrument refers to the side of the instrument nearest the panel and right and left refers to the constructor's right and left as he sits facing the back of the set in wiring up.



it on from there over to the top terminal of the jack switch R1.

Next connect a wire to the front bottom connection of the stator of the variometer A and extend it over to the left-hand terminal of the condenser G.

Then run this over to the right rear connection of the socket Q1. This terminal is the grid terminal of the socket. Then run an extension of this same wire over to the bottom terminal of the jack switch R1.

Next connect a wire to the bottom screw of the metal bracket that holds the variometer A on to the panel over to the front connections of the amperites, O1, O2, O3 and O4 and end it up at the bottom terminal of the jack switch R2.

Then run another extension of this wire over to the front left connection on the socket Q2.

Next run a wire from binding post No. 2 over to binding post No. 3, extending it over and attaching it to binding post No. 5 and from here over to terminals marked B+ on the two resisto-couplers K1 and K2 and from here in between the two resistances L2 and M2 and in between the two sockets Q4 and Q5 and attaching it to the top terminal of the jack switch R2.

Next, solder the connections between the back terminal of the amperite O1 and the right front terminal of socket Q1. Do the same with amperites O2, O3, O4 and sockets Q3, Q4 and Q5 respectively.

Then solder one terminal of the grid condenser H to the right rear terminal of socket Q2 and run a connection between the remaining terminals of the condenser H and the bottom connection on the coil BCD and extend this wire over to the right-hand stator connection on the rear unit of the variable condenser E and F.

Next run a connection from the rear terminal of the grid-leak I to the right rear terminal of the socket Q2.

Then run a wire from the front terminal of the grid-leak I to the right front terminal of the socket Q2 and extend this wire over to the right-hand terminal of the rheostat P.

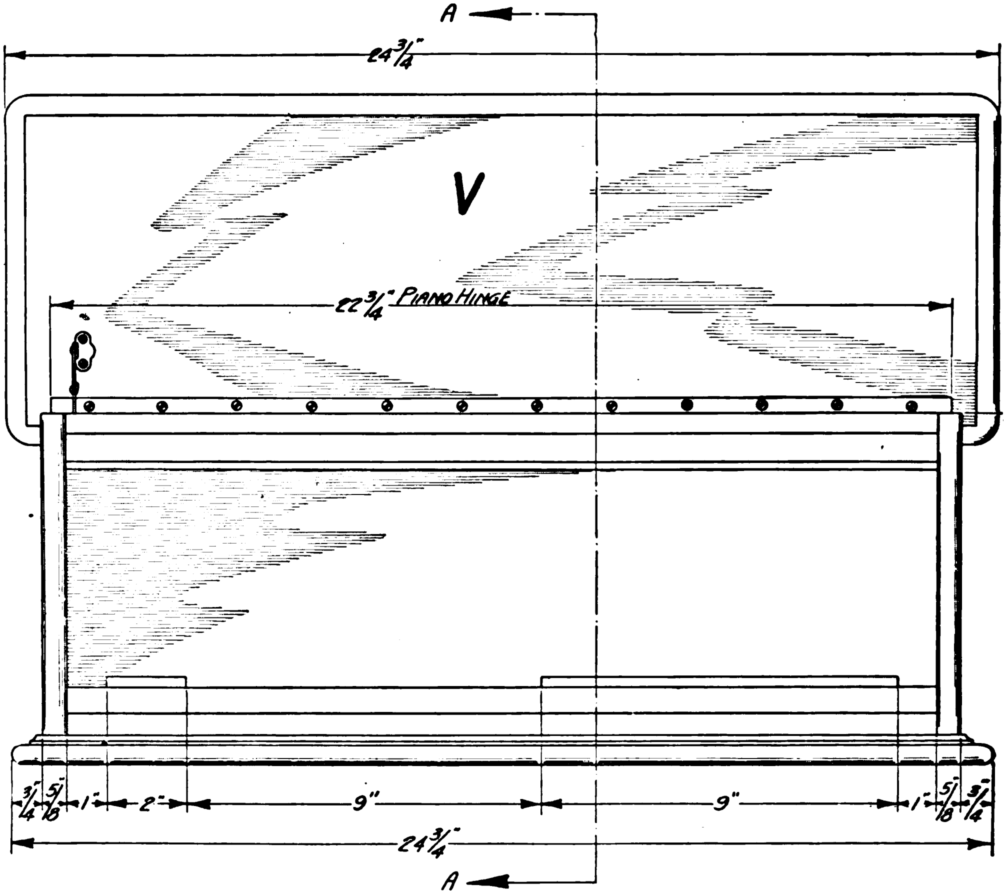
Next run a wire from the front left terminal of the socket Q1 extending it to the front left terminals of sockets Q3, Q4 and Q5.

Then run an extension of this wire from a point between sockets Q3 and Q4 back between the sockets and between the two resistances L1 and M1 and attach it to binding post No. 4.

Another extension of this main wire should be run to the left-hand terminal of the rheostat P.

Next run a wire from the top front terminal of the coil BCD down to the left rear terminal on the socket Q2 and extend this wire to the terminal marked P on the transformer J, and run a further extension of this wire between the two sockets Q2 and Q3 and attach it to the left-hand stator terminal of the front section of the condenser E and F.

Next attach a wire to the terminal marked B+ of the transformer J and run it over to



binding post No. 6. Now attach a small wire to the right rear terminal on socket Q3 and extend it over to the terminal marked G on transformer J.

Then connect a wire from the terminal marked F– on transformer J over to the wire connecting binding posts No. 2 and No. 3.

Next solder the connections between terminal G on the resisto-coupler K1 to the terminal marked P which is the left rear terminal of socket Q3.*

Next solder the connection marked P on the resisto-coupler K1 to the terminal marked G which is the right-hand rear terminal of the socket Q4. Then do the same thing with the two sets of terminals on resisto-couplers K2 and the plate and grid terminals of the sockets Q4 and Q5.

Next run a wire from the top left-hand connection to the coil BCD and extend it down and to the left attaching to binding post No. 7. The top right-hand terminal of the coil BCD should be run down and connected to the left rear terminal of socket Q1. The front middle tap on the coil BCD should then be run down and extended forward to the bottom screw on the frame of the condenser E and F which attaches to the two rotors.

Next run a wire connecting the two terminals marked B+ on the resisto-couplers K1 and K2 and extend this over and attach it to the adjacent part of the wire running to binding post No. 5. Then you can connect the two terminals marked F on the resisto-couplers K1 and K2 with a wire that extends also over to binding post No. 8 and to the top terminal of jack S. The bottom terminal of the jack S should connect to the left rear terminal of the socket Q5. This completes the wiring and the set is ready to be installed.

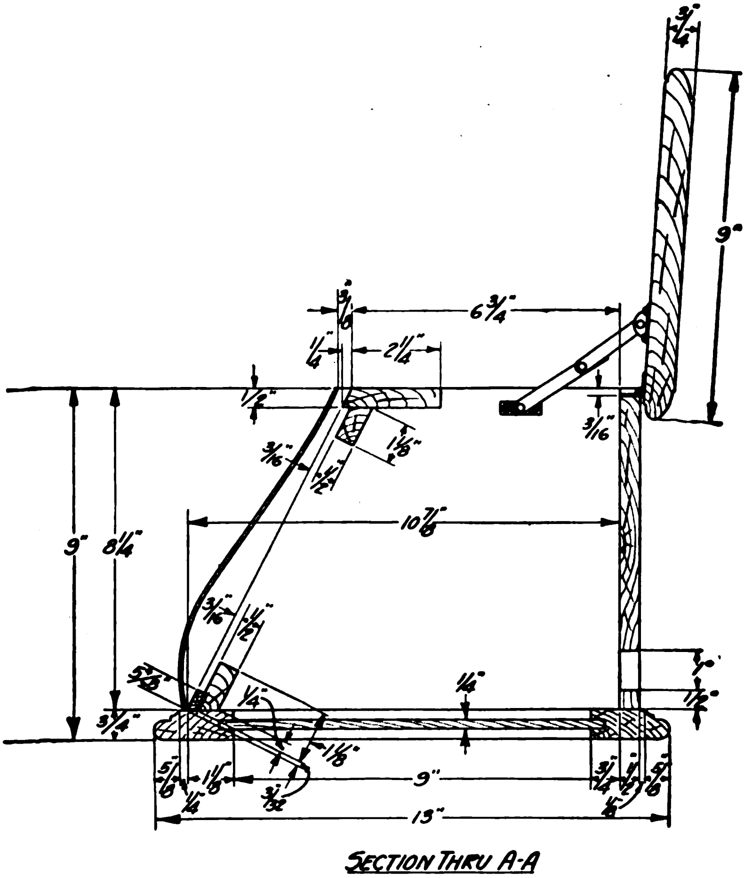
How to Install the Set

. After the wiring has been completed the set should be inserted into the cabinet. In placing the set into the cabinet grasp the baseboard and turn it so that it is in a vertical position with the large coil BCD pointing at the cabinet.

Then with a circular motion insert the coil

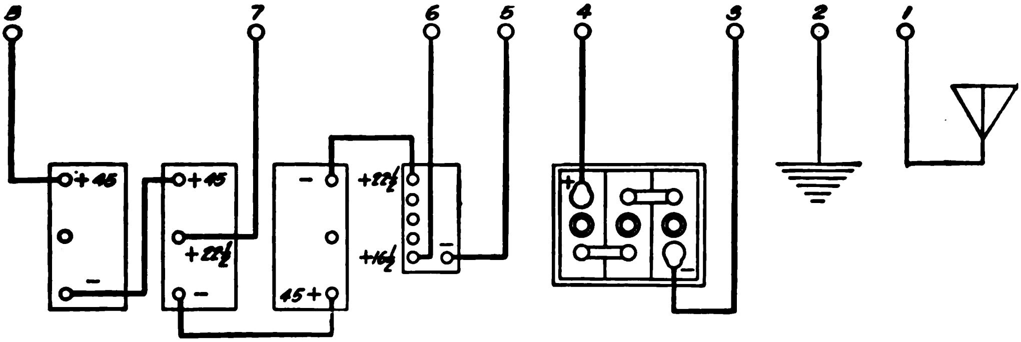
---

*Notice that the resisto-couplers are used in a reversed order and that the plate resistances are used in a position shunting terminals marked G and F while the grid terminals are used in a position shunting P and B+. This in no way affects the operation of any of the instruments but it facilitates the wiring and makes a much more compact job.



THE DIMENSIONS FOR THE CABINET

Figure 11: *This diagram (which contains the top, front, and side measurements for the walnut cabinet) may be turned over for construction to a competent cabinet maker who can build it from these directions exactly the right size for the panel.*



HOW TO HOOK UP THE BATTERIES

Figure 12: *This drawing prevents the builder from making mistakes in connecting the batteries to the terminals of receiver. Follow these instructions and the set will be hooked up correctly because the terminals shown in the wiring diagrams are marked with designations that correspond with the numbers given here.*

underneath the upper ridge on the cabinet and gradually bring the baseboard U to a horizontal position again. This is the only way that you can get the set into the cabinet. Make sure that the battery connection blocks fit exactly in the two rectangular holes cut in the back of the cabinet for them and push the whole unit back into place tightly so that you can screw in the six wood screws that hold the panel in place.

Then insert the three amperites O1, O2 and O3 in their proper mountings and place O4 in its proper mounting. Place the four Bradley units L1 and L2, M1 and M2 in their proper positions as shown in the diagram.

Next insert a UV-201-a tube in the socket Q1 and use the same type of tubes with sockets Q3 and Q4. In socket Q2 use either a UV-200 or a C-300 "soft" detector tube and in socket Q5 place a UX-112 power tube.

The batteries, antenna and ground connections are now ready to be attached. If you are using the set with an aerial over sixty feet in length, turn the jack switch R1 to the left. If you are using a short indoor aerial of less than this length, turn this switch to the right. The "off" position for the battery switch jack R2 is to the left and the "on" position is to the right. This switch should be left off when the set is not in use.

Next connect the batteries and the antenna and ground connections exactly as shown in Figure 12.

Then insert the loudspeaker plug in the jack S and you are ready to use the set.

Operating Data

First turn on the rheostat P a little over half-way and then turn the battery switch R2 to the right and all the tubes should light.

Next revolve the dial Z to the proper setting as indicated by the tuning chart in Figure 13 to the particular wavelength that you wish to receive. This should immediately bring in the station you want to hear. The small dial which controls the variometer A may then be used as a volume control for bringing up the strength of signals to the desired volume. The small dial on the rheostat P should then be adjusted for the best quality. This dial will also affect the selectivity of the receiver. When tuning for distant stations it should be set a little higher than when receiving locals.

The loudspeaker recommended should be one of the cone-type that will reproduce the low tones that really make broadcast reception enjoyable. The author uses a Western Electric 540 A.W. or a Bosch "cone" for this purpose.

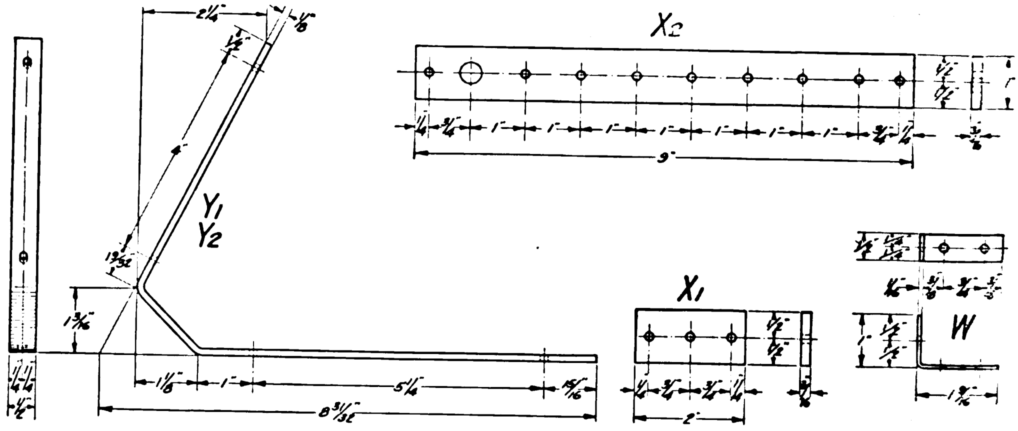
The grid-leak I should be adjusted by turning the knob in an anti-clockwise direction until it is turned all the way up and then turn slowly back until there is a click heard in the loudspeaker, at which point the knob should be turned down slightly farther about an eighth of a turn.

Then the final adjustment should be made on a distant station when it will materially affect the amplification that the operator can obtain. Do not turn this grid-leak down too far, however, as it will broaden tuning and affect the selectivity and sensitivity.

It is recommended that wherever possible this set should have both a regular outdoor antenna and a short antenna. When static conditions are too poor for reception on the outdoor antenna, the indoor antenna can be switched on and the small switch R1 turned over to the right. Never tune in a station with more volume than is suitable for the size of room in which the receiver is used.

In turning off the set all that is necessary to do is to turn the jack switch R2 to the left when the batteries will be disconnected and the filament circuits broken.

This receiver cannot radiate into the antenna



OVER-ALL LENGTH = APPROXIMATELY 13⅞"

DETAILS OF THE BRASS BRACKETS AND THE CONNECTION BLOCKS

FIGURE 14: *This drawing gives the necessary data for making the insulated blocks on which the binding posts are to be mounted. It also gives the dimensions for the large and small brass brackets that are used to fasten the large and small panels to the baseboard.*

and therefore it cannot disturb the user's neighbors.

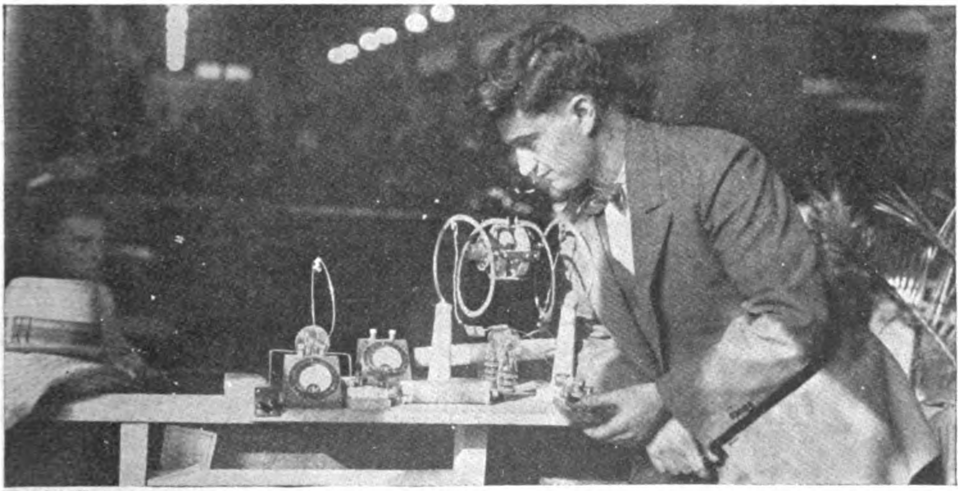
For local reception the antenna may be left off altogether and the ground wire disconnected from its usual place and attached to the antenna binding post No. 1. The set will then tune in the usual manner and all the local signals may be brought in with loudspeaker strength.

After the operator has become familiar with the tuning chart and the dial settings for the tuning dial Z he should have no difficulty in tuning in the local stations or in fact, any of the distant stations within range while local stations are broadcasing.

In New York City the author uses this receiver and finds it easy to tune in KDKA and WJAR while the local stations WAHG and WGBS are going full blast. It is also easy to tune, in New York City, the Philadelphia stations WOO and WIP, the Chicago station KYW, and the St. Louis station KSD while WEAF and WNYC are on the air. This is a good test for selectivity as the reader will note if he compares the wavelengths of these various stations. During the whole summer all of the main middle west stations and quite a few west coast stations have been picked up and held during the local transmission in the evenings with loudspeaker volume and fine tone quality when the static conditions were not too great. The sensitivity and tone quality of the receiver are really remarkable.

HERE ARE THE PARTS YOU WILL REQUIRE—

A—General Radio variometer, type No. 269 equipped with General Radio small rheostat knob;
B, C and D—plate, intermediate and grid coils of Precision Octaform coil set;
E and F—Amsco special double-unit condenser, No. 1814, each section .0003 mfd.;
G—Micamold fixed condenser, .00015 mfd.;
H—Micamold fixed condenser, .00025 mfd.;
I—Bradleyleak, ¼ to 10 megohms;
J—Amertran De Luxe audio transformer for first stage;
K1 and K2—Daven resisto-couplers (new type which incorporates .1 mfd. condenser concealed in base);
L1, L2 and M2—Bradleyunits, type 250-R ¼ megohm;
M1—Bradleyunit, type 500-R, ½ megohm;
O1, O2 and O3—Amperites No. 1A;
O4—Amperite No. 112;
P—General Radio rheostat, type No. 214A, 7 ohms equipped with General Radio small rheostat knob;
Q1, Q2, Q3, Q4 and Q5—Benjamin standard "Cle-ra-tone" sockets;
R1 and R2—Carter jack switches No. 2;
S—Carter open circuit jack No. 101;
T—Universal decorated panel, 8 by 22 inches;
U—hardwood baseboard (furnished with cabinet);
V—Corbett special sloping-panel cabinet:
W—small brass brackets (See Figure 14):
X1—antenna connection block, 1 inch by 2 inches (See Figure 14);
X2—battery connection block, 1 inch by 9 inches (See Figure 14);
Y1 and Y2—large brass brackets (See Figure 14);
Z—Fynur vernier control knob and dial;
Eight Eby binding posts



Kadel & Herbert

AN EXPERIMENTAL ONE-METER TRANSMITTER

The range of this set is quite as limited as its wavelength, however, since it reaches only to the small receiving set on the left. When the transmitting key is pressed the small bulb at the top of the Hertzian loop lights up to show visibly the reception of the signals.

Where Fortunes Wait

Inventions that are needed in the field of radio

A Re-chargeable "B" Battery

1. A "B" battery that may be charged at home by inserting a new supply of chemicals—thus avoiding the necessity of purchasing a new battery.

* * *

A Tube-filament Renewer

2. A device that will enable the radio fan to renew, without great expense, the burned-out filaments of his vacuum tubes.

* * *

A Self-tuning Receiver

3. A complete receiving set with an automatic dial device, similar to the automatic telephone, that will tune in electrically the broadcasting stations by merely dialing the station call letters.

* * *

A Filament Current Supply from the Lighting Circuit

4. A really satisfactory method for obtaining proper filament supply for vacuum-tube receivers that are used as a source of power to the alternating current lighting lines and that can be attached to any receiving set without change in the receiver design.

* * *

A Simple Static Eliminator

5. A device that can be used in conjunction with a receiving set that would eliminate static and yet not increase the number of controls necessary for tuning in the signal.

* * *

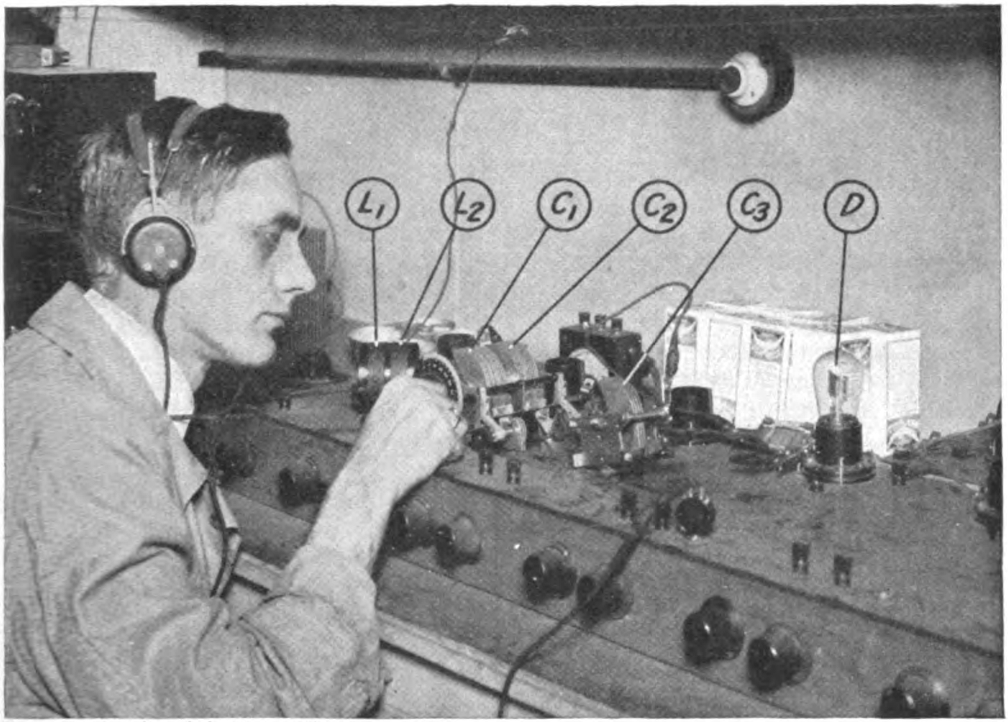
Vacuum Tubes Without Filaments for Amplification

6. A new principle for obtaining a pure electron stream in a vacuum tube that will be modulated by an externally applied current, without the use of a filament or batteries.

* * *

A Solution to Super-regeneration

7. A circuit modification of the Armstrong super-regenerator which will obtain full benefit of super-regeneration without critical operation and without distortion.



From a photograph made for POPULAR RADIO

TESTING OUT A SET-UP THAT EMPLOYS SINGLE-CONTROL

In this picture is shown a working model on the experimental bench of the single-control circuit shown in Figure 2. The designating letters attached to the instruments are the same as those shown in the diagram.

HOW TO IMPROVE

Broadcast Reception

VIII: How to Increase Operating Distance

This series of tuning-circuit articles was prepared by one of the most experienced radio engineers in the world *for the special benefit of the broadcast listener.* The preceding seven articles of this series include: "The Effects That Occur in the Transmitting Station," August, 1924; "Helpful Hints on Tuning," September, 1924; "Oscillations in the Receiver," October, 1924. "Noises That Come in With the Waves," January, 1925; "Cutting Down Spark Interference," February, 1925; "Increasing the Selecting Power of Your Receiver," April, 1925; "How to Reduce Interference," October, 1925.

By JOHN V. L. HOGAN

WE have seen in the preceding articles of this series that one of the most effective ways of reducing station interference, including both "cross-talk" from broadcasting stations and code signals from spark transmitters, is by the use of the inductively-coupled tuned antenna circuit.

This improvement ordinarily complicates the operation of a receiving set by introducing an additional tuning element, such as a variable condenser that requires separate adjustment. It has been found entirely feasible, however, to simplify the control of such a multiple-tuned-circuit receiver by equalizing or matching the circuits and using multiple condenser or inductor units that will adjust the tuning of all the circuits with one motion.

In the September article I described the simultaneous control of the series type of tuned antenna circuit and a tuned secondary circuit connected to the input terminals of a simple audion detector receiving set. This particular form of tuned antenna circuit is most effective when fairly large antenna systems are used for the reception of relatively high-frequency (short) waves.

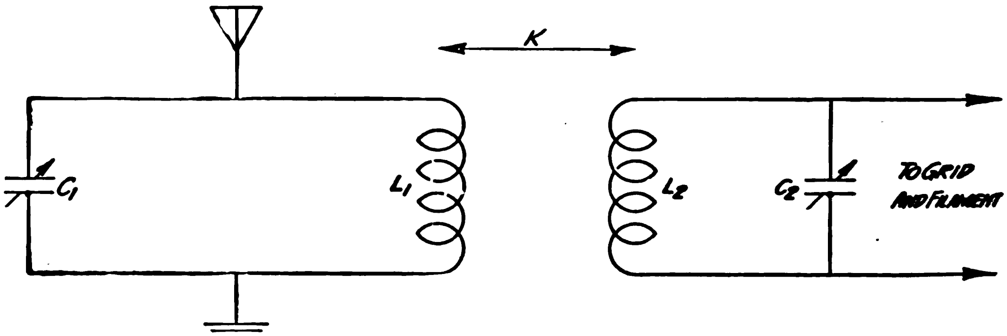
When the strength of the signal wave as it arrives at the receiving point is great enough to permit one to substitute a smaller antenna, some additional freedom from interference and "static" or strays is obtained by that change alone.

The combination of the small antenna with separate tuning of its circuit is extremely helpful in overcoming quite severe interference difficulties, and thus may be of substantial aid in "getting distance;" but the series connection of the tuning condenser above referred to is no longer satisfactorily efficient. If broadcasting waves are to be received upon a relatively small antenna (such, for example, as a single wire not more than thirty or forty feet long), it is usually best to use the shunt-condenser connection shown in Figure 1.

This simple circuit may equally well be used with single control for tuning both primary and secondary, by following the principles explained in the preceding article of this series. Noting that the capacity of the antenna wire with respect to ground acts to increase the effective capacity connected across the terminals of the primary coil L_1, it is clear that if the secondary coil L_2 is made identical in size one should connect an additional condenser across the secondary terminals in order to make the condensers C_1 and C_2 tune alike.

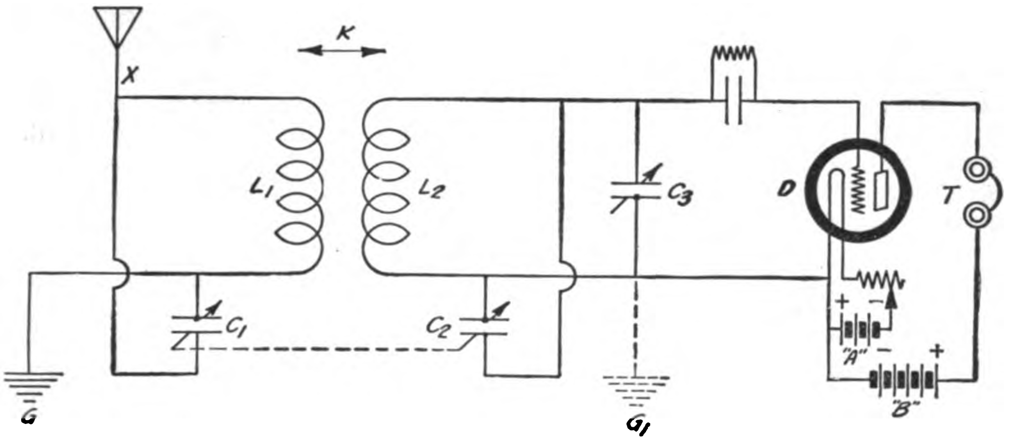
Figure 2 shows an arrangement in which C_3 is added for this purpose, the two tuning condensers being C_1 and C_2 as before.

If the supplemental or compensating condenser C_3 is made to equal the effective capacity of the antenna (less whatever small effect is produced by the detector), and if the coils L_1 and L_2 as well as the tuning condensers C_1 and C_2 are alike, the settings of C_1 and C_2 will have the same scale-reading for best reception of any wave within their range. Thus it is feasible to use a double condenser that has a common shaft to turn both rotary sections, in place of C_1 and C_2, and so to tune both circuits by a single control. Changes in the coupling between L_1 and L_2 will affect the tuning of the two circuits and so may change by a scale division or two the resonance point for any particular



THE "SHUNT CONDENSER" TUNED ANTENNA CIRCUIT FOR SMALL AERIALS

FIGURE 1: *The connections at the right may be taken to a detector tube, through the usual grid condenser and leak, or to the first tube of a radio frequency amplifier.*



HOW TO USE "SINGLE CONTROL" OF TUNING IN THE SHUNT-CONDENSER CIRCUIT

FIGURE 2: *A small series condenser may be added at X. A simple detector tube is shown, but the first tube of a tuned or "untuned" radio frequency amplifier may be substituted.*

station. However, the tuning of the two circuits will remain "in step" because the inductions are equal and, therefore, their reactive effects upon each other are the same.

Should you find it difficult to balance the two circuits exactly, the compensating condenser C_3 may always be used as a supplementary adjustment to bring the tuning to exactly the best point.

The vacuum tube detector of Figure 2 is the simple non-regenerating type. In order to gain selectivity, and thereby increase operating distance at times when interference is severe, the separately tuned antenna circuit is shown. There is another very useful way of getting greater freedom from interference and at the same time increasing the responses to desired signals, and that is by adding regeneration or feed-back to the receiver.

Fortunately for our present purposes the desirable regenerative selectivity is obtained in a way that may be used to supplement rather than to replace the selective power gained by the separately tuned antenna circuit. Thus we may utilize both of these methods to reduce the harmful effects of interference and so get better results from the two in combination than could be had from either used alone. Not only will the reception of signals from distant stations be improved because of the reduction of interference, but the characteristic amplification that comes with regeneration will make the desired signals louder.

The reasons for these results may easily be understood if we find out a little more about regenerative or feed-back effects.

Let us look for a moment at a simple vacuum tube circuit such as that of Figure 3.

Here, at the left are a coil, L_1, and a variable condenser, C_1, connected to the grid G and filament F of the vacuum tube. The circuit containing these elements is the grid-filament or input circuit (often called simply the "grid circuit") and is variably tuned as shown. The usual "A" battery is used for heating the filament, and may be supplemented by a filament rheostat for temperature control. The plate P of the vacuum tube is connected through a variable inductance coil, L_2, the indicating meter M and the battery "B" to the filament; these elements are in the plate-filament or output circuit.

If radio frequency currents are set up in the input circuit, as (for instance) by coupling coil L_1 to an antenna-ground circuit, they may be resonated up to a maximum value by tuning the circuit with the aid of the variable condenser C_1. Then the rapidly alternating and relatively intense potentials applied between the grid and filament will, because of the "controlling" action of the grid and the normal amplifying characteristic of the vacuum tube, cause corresponding pulsations or radio-frequency currents in the plate or output circuit. If the meter M is of the sort that responds to radio-frequency currents, their presence and amount will be indicated by the scale reading of the meter.

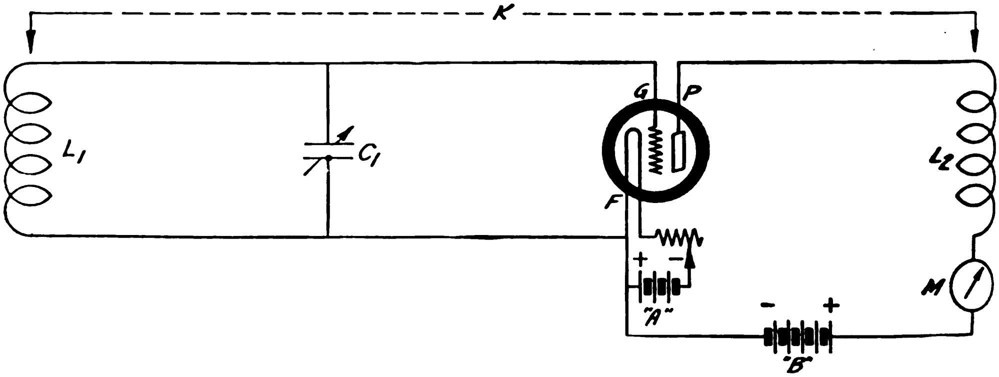
Now suppose that the coil L_2 is moved over toward the coil L_1, thus making of the pair a transformer. We may look on the coil L_2 as a primary winding and L_1 as a secondary. Part of the energy of the radio currents in the output circuit, passing through L_2, may thus be fed back into the input circuit containing the coil L_1, and (by correctly selecting the relative position of the coils) used to build up the amount of radio-frequency current of the frequency to which the grid circuit is tuned.

The augmented current in the input circuit, acting through the tube, will naturally cause larger radio-frequency currents in the plate circuit, and part of the energy of these will in turn be fed back to amplify further the oscillations in the input circuit.

This process of radio-frequency amplification, involving the amplifying power of the tube itself and the feeding back of plate-circuit energy, is repeated over and over again, and produces a very large increase in the strength of the radio-frequency impulses applied to the circuit. The power used to produce the magnification of signal strength comes from the B battery of the tube system, and the final effect is much as though the resistance of the entire circuit had been artificially reduced.

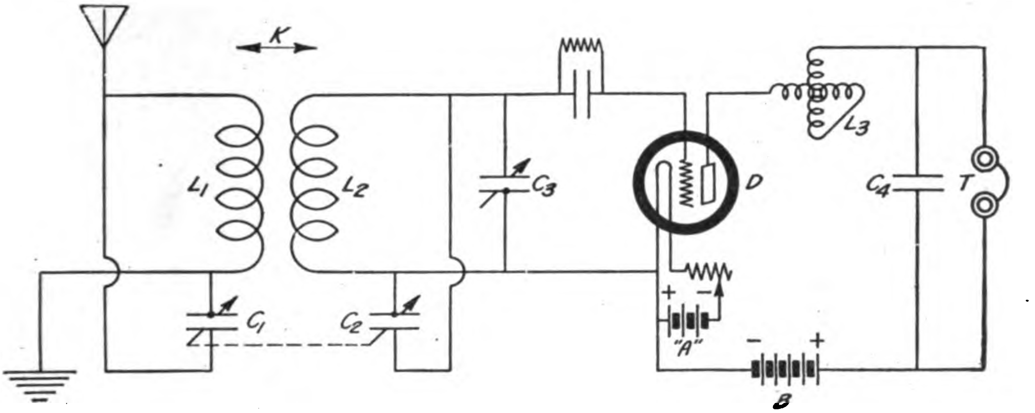
One of the most interesting things about this regenerative system is that its useful property of reducing the apparent resistance of a circuit occurs at the frequency to which it is tuned. That is, such a system will oppose relatively little of the absorbing or power-wasting property (that characterizes electrical resistance) to currents of the frequency to which it is tuned. On the other hand, it will not permit the flow of such relatively large currents of other frequencies.

Thus you can see at once that the useful amplifying power of the regenerative circuit is particularly valuable because it occurs at the tuned frequency, and, unlike some other forms of amplification, does not magnify impressed currents of other frequencies. In that way regeneration contributes to sharpness of tuning and is a powerful aid in reducing interference effects. Its multiplication of signal strength is also very helpful in-



HOW REGENERATION MAY BE USED TO INCREASE SIGNAL STRENGTH

FIGURE 3: *A simple vacuum tube circuit in which regeneration may be used to increase signal strength and sharpness of tuning.*



A GOOD CIRCUIT FOR LONG DISTANCE RECEPTION

FIGURE 4: *The regenerative detector applied, with variometer L_3 in the plate circuit, to the single-control arrangement of Figure 2. This easily-handled circuit, with one stage of audio amplification added, is very effective for long distance reception.*

directly for solving interference problems, for the increased sensitiveness that it provides makes it possible to use quite loose coupling between resonant circuits and thus to minimize the breaking-in of strong spark signals or of cross-talk from nearby broadcasting transmitters.

The arrangement described in connection with Figure 3 called for inductive coupling between coils L_1 and L_2 in order to facilitate the transfer of energy back from the plate circuit to the grid circuit. It is not necessary to have such inductive coupling for this purpose. One of the most useful arrangements of the regenerative circuit utilizes the capacity of the tube electrodes as a coupling for feedback.

Bearing in mind that a condenser is essentially a pair of conductors insulated from each other, you can see at once that the grid and the plate of the tube (being relatively close together in the evacuated space) are in effect the two plates or electrodes of a small condenser. Consequently, if we may use the language of the old art for a moment, a positive charge impressed upon one will induce a negative charge on the other. This is equivalent to saying that the condenser-effect or capacity between the grid and plate may provide an electrical coupling between the grid circuit and the plate circuit. Given such a coupling, we now know that it may be used to feed back energy for regeneration.

One of the simplest ways to get sufficient energy across this grid-plate capacity is to put a variable coil such as a variometer in the plate-filament circuit (as at L_2 in Figure 3) and with it adjust the natural frequency or tuning of that circuit. As the inductance is increased, the plate circuit will approach more and more closely to resonance with the tuned frequency of the input circuit and more and more radio-frequency energy will be developed in the output. As the energy thus increases the potentials applied to the grid-plate capacity will increase, and more and more energy will be fed back right up to the point where oscillations begin and (in ordinary broadcast receiving) heterodyne squeals or whistles are consequently heard.

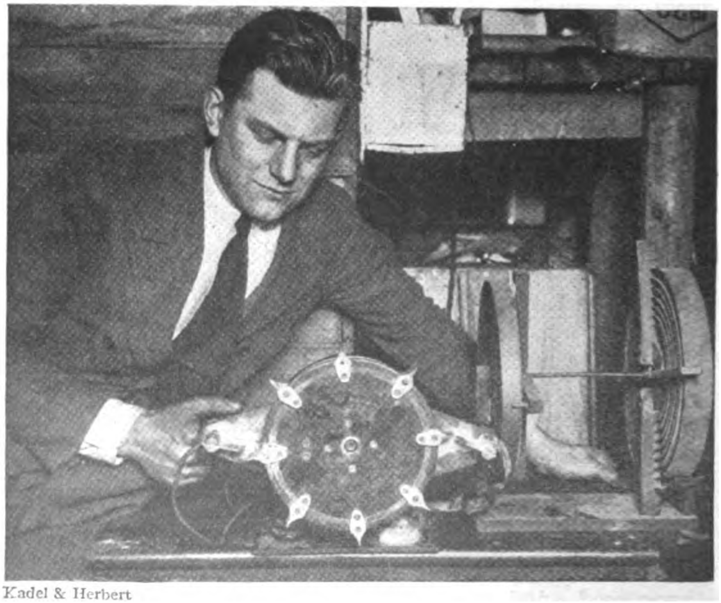
Figure 4 shows how this "tuned plate circuit" method of producing and controlling regeneration may be applied to a single control circuit like that of Figure 2. The variometer is indicated at L_3, and another additional element, a condenser of say .002 microfarad, is shown connected across the telephones at C_4.

Such an arrangement is particularly desirable because the plate circuit variometer is very efficient at the high wave frequencies (short waves) used in broadcasting and because its adjustment produces little if any effect upon the tuning settings of the circuits including C_1 and C_2. Yet the amplification and sharpness of tuning obtained are extremely helpful.

Audio-frequency amplification may, of course, be added to the receiver of Figure 4 by substituting the primary of the audio coupling transformer for the head telephones illustrated. It is fair to say that such an arrangement, having only one audio stage (two tubes in all) and used with head telephones and a moderately good antenna system, will give surprisingly loud signals from distant stations, together with relatively great freedom from interference of all kinds. For loudspeaker operation additional amplification may be added, but this should be of both the radio and audio-frequency types in order to get the best overall results.

The same principles of loose coupling and multiple tuned circuits, with or without unified tuning control, and of regenerative amplification and tuning-sharpness improvement, may be applied to a great many variations of circuit arrangement.

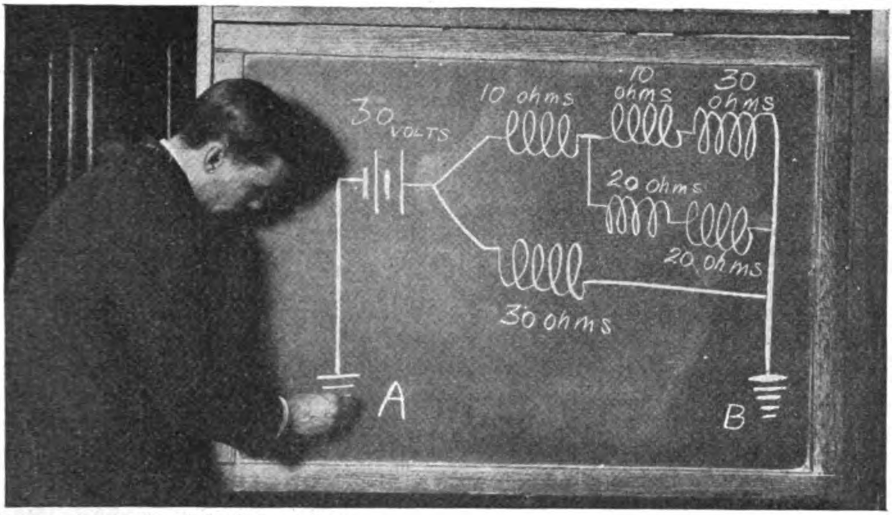
It would be outside the scope of this series of articles to go into the details of the sharply and broadly tuned radio-frequency amplifier combinations, and the various other cicuit modifications, that can be worked out along the lines suggested. In closing the series, then, I hope that I have succeeded in pointing out some of the specific paths that can be followed in our persistent and progressive march towards the goal of perfect broadcast reception.



Kadel & Herbert

AN OLD ROTARY SPARK THAT BROKE ALL RADIO RECORDS IN ITS DAY

This peculiar outfit is an old type rotary spark gap which was used when radio was in its infancy. This type was very popular in 1907, and this particular example was used and still is owned by Kenneth Hewitt, known to brass pounders as 2RK, a world's record holder both for transmission and reception. A huge spark coil delivering 36,000 volts was used to operate it and it has over one kilowatt of power.



From a photograph made for POPULAR RADIO

SERIES-PARALLEL COMBINATION

FIGURE 1: *It is more difficult to calculate the total resistance of a combination circuit as shown above than the simple one shown in the preceding article. The solution to this problem appears in the text.*

WHAT "CURRENT" MEANS IN RADIO

Chalk Talks in Radio—No. 3

The short, informative articles in this series are written for the radio novice. They embrace the electrical background of radio work. Keep them for reference

By J. W. GOOSTREE

BEFORE we take up the next electrical subject, I will tell you how I solved the circuit problem in our last chalk talk.

I twisted and turned the diagram about until I divided it into four arms and redrew it as shown in Figure 1.

This is what I made of it:

10 ohms on the top arm at the right plus 30 ohms beside it equals 40 ohms.

20 ohms plus 20 ohms on the center arm equals 40 ohms.

Multiply these two results together and you get 1,600.

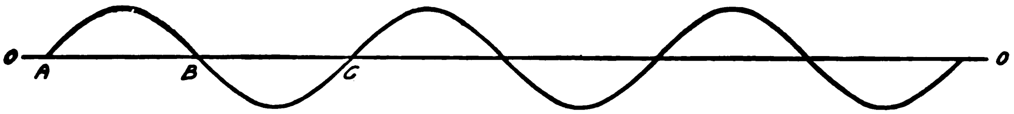
Divide this result by 80 (the sum of the resistance of the two arms) and you get 20 ohms.

Add to this result, which is the resistance of the two upper arms at the right, 10 ohms, which is the value of the top arm at the left. This equals 30 ohms.

This resistance is multiplied by the resistance of the lowest arm—30 times 30 equals 900.

900 divided by 60, which is the combined resistances of the upper arms added to the resistance of the lowest arm, equals 15 ohms.

The combined resistances, therefore,



A GRAPHIC ILLUSTRATION OF ALTERNATING CURRENT

FIGURE 2: *Alternating current flows through a circuit in pulses of continuously reversing polarity. In the diagram above it is shown starting at A at zero and increasing and falling again to zero at B, with one polarity. Then it reverses in polarity and the same process is repeated from B to C, and so on continuously.*

from A to B are equal to 15 ohms.

30 volts divided by 15 ohms equals 2 amperes.

30 volts times 2 amperes equals 60 watts.

Now you have the answer to the problem in CHALK TALK NO. 2.

Perhaps you have wondered about symbols to represent current.

Direct current may be likened to the flow of a river that runs from the North Pole (+) to the South Pole (—).

A simple symbol for direct current is a straight line with the poles at either end, like this:

+——— –

Direct current flows from the positive (+) terminal of a battery or generator, through the external circuit to the negative (—) terminal and from the negative (—) to the positive terminal (+) within the battery or generator.

Alternating current is different. It is waving or varying in intensity and must be represented in a way that indicates its regular changing character.

In Figure 2 the line A, B, C gives you a picture of an alternating current.

Starting at zero in the figure the line rises to its maximum in one direction, and returns through zero to its maximum in the opposite direction. In this figure A to B is a alternation, and A to C one complete cycle.

Pulsating current travels along the circuit, like a frog down a path, in jerky jumps, but always in the same direction. Lop off all the alternations below the zero line in Figure 2 and you have a fair picture of "pulsating" current.

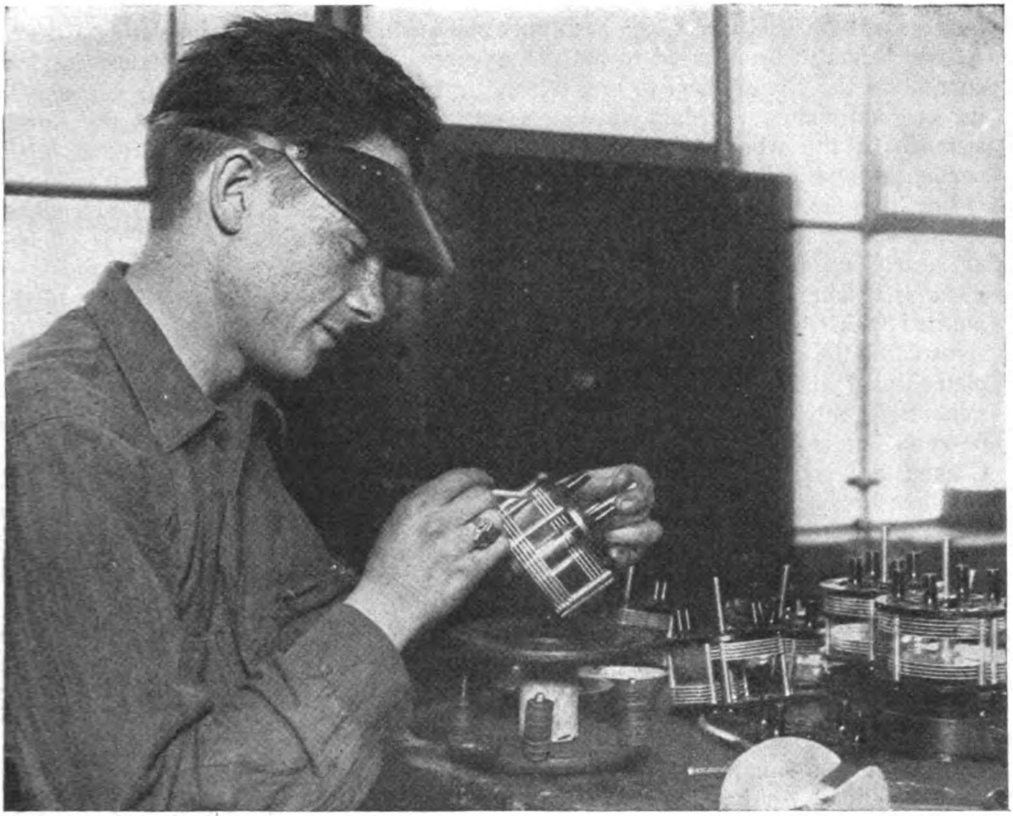
Variable, high-tension, high-frequency and other kinds of current will be explained in a later talk.

The next problem is how would you connect five 20-ohm resistances in a 50-volt circuit to get 100 watts?

The answer will appear in CHALK TALK NO. 4, in which I tell about more symbols.

What Helpful Hints Can *You* Give to Your Fellow Radio Fans?

ALL owners of receiving sets—sets either built at home from plans and specifications published in POPULAR RADIO or ready-made sets—are invited to tell their fellow readers of this magazine about their successful experiments in getting broadcast reception. Have you discovered some little kink that will be of service to your neighbor? Tell him about it—in a letter addressed to the Listening-In Editor of POPULAR RADIO, 627 West 43rd Street, New York City.



Kadel & Herbert

ASSEMBLING CONDENSERS

Great care must be taken in assembling the condenser units so that the spacings of the rotor and stator plates are kept uniform. This is a tedious job that must be done by an experienced operator.

WHAT EVERY RADIO EXPERIMENTER SHOULD KNOW ABOUT

CONDENSERS

PART II

Little known data about variable condensers and about the "low-loss" fallacies as applied to this type of instrument

By SYLVAN HARRIS

WHATEVER "low-loss" and "dielectric losses" in regard to varible condensers may mean to you, recent check ups of methods for measuring condenser resistances (some of which are explained in this article) will upset many of your ideas about condenser efficiency.

The simplest method that is used in attempting to measure the resistance is illustrated in Figure 1.

The condenser to be measured is placed in series with a coil, a current meter and a variable resistance. This circuit is excited by the oscillator at the desired wavelength. If the meter used is a current-squared meter, the resistance R, which has to be inserted to make the current in the circuit drop to one-fourth its original value, is equal to the resistance of the whole circuit, including condenser and coil.

For the next step in the method, a special condenser is built, which consists as nearly as possible, of plates only. That is, all the insulating material is omitted which it is possible to omit. In some cases the condenser consists of two plates hung on silk threads. The resistance of this condenser is assumed to be zero. It is inserted in the circuit at C, and a second determination of the resistance is made. The difference between the two measurements is said to be the resistance of the first condenser, since the second was assumed to have zero resistance.

Now let us consider the faults.

In the first place, it is absurd to suppose that any piece of apparatus has zero resistance. The argument may be raised that it is small enough to neglect. But it is not. As has been shown before* there are other losses in condensers besides dielectric losses, and the special "standard" condenser surely has some of these.

Furthermore, on account of the fragile construction of the "standard," it generally has to be small. Figure 4 shows what this means. Four condensers of the same make and design, and all with the same amount of insulating material, were measured for resistances and the results were plotted in this curve. The condensers differed only in the number of plates and length of shaft. It is seen that the smaller condensers have inherently the higher resistance. Hence the resistance of our "standard" is likely to be much higher than we imagine.

Another cause of error in this method is the high resistance of the coil and meter, as compared with the resistance of the condenser. Suppose the resistance of the coil, meter, and unknown condenser is 10 ohms, and the resistance of the coil and meter (assuming the "standard" to have no loss) is 9.5 ohms. The resistance of the unknown will then be

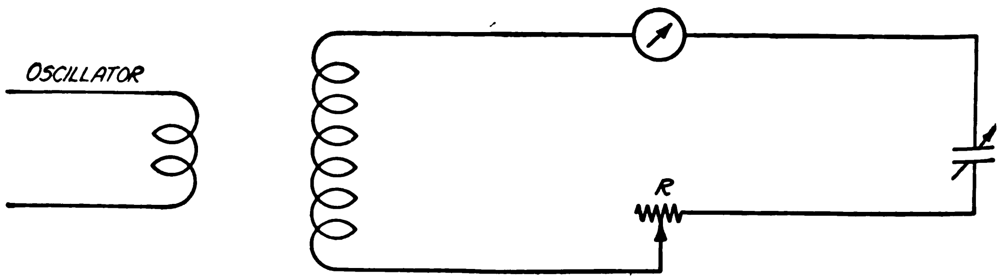
$$10 - 9.5 = .5 \text{ ohm}$$

Now a small error in the measurement with the standard, such as .1 ohm, will represent an error of only one percent in the actual measurement, but this error will increase to 20 percent when the subtraction is made to find the condenser resistance. Thus,

$$\frac{0.1}{9.5} \times 100 = 1\% \text{ (roughly)}$$

$$\frac{0.1}{0.5} \times 100 = 20\%$$

This is one of the difficulties that had to be overcome in making the measurements described in this and the preceding articles and anyone wishing to learn the details of the method may consult

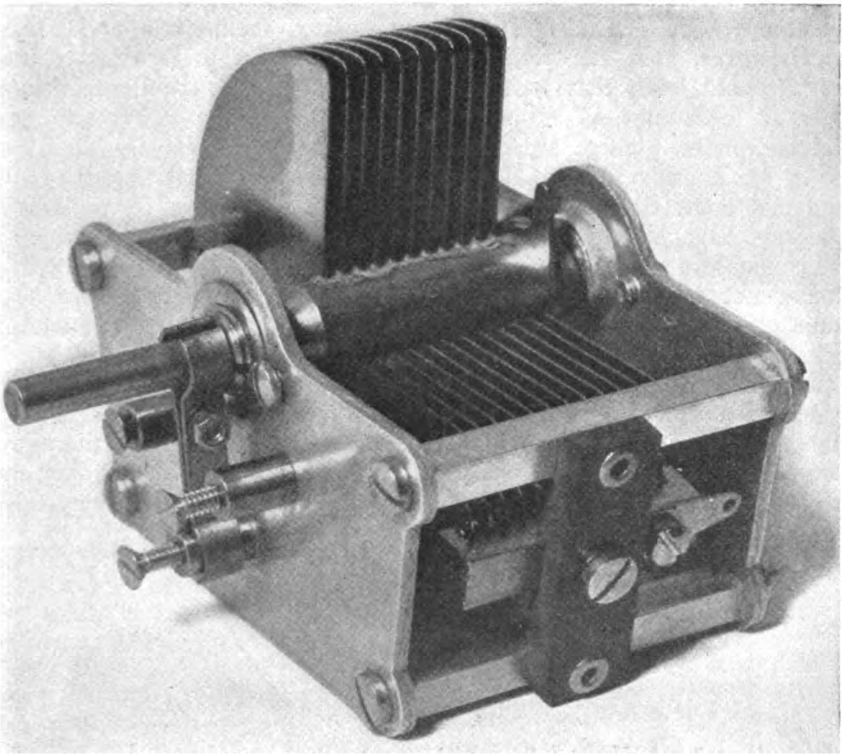


THE AUTHOR'S METHOD OF MEASURING CONDENSER RESISTANCES

FIGURE 1: *This diagram shows the general arrangement of the testing circuit for obtaining the efficiency of the variable condenser at high frequencies of the order used in radio receiving sets for broadcast reception.*

---

*See POPULAR RADIO for February, page 130, Figure 3.



AN EFFICIENT METAL END-PLATE CONDENSER

Figure 2: *This condenser (which is a well-known make) shows the construction of a variable type that employs metal end plates with two small slabs of insulating material. This condenser really is an efficient piece of apparatus from both the electrical and mechanical standpoint.*

the more technical paper in the I. R. E. Proceedings.†

To overcome this difficulty the resistance of the measuring circuit must be as low as possible. At any rate it must not be greater than the resistance that is being measured. This also means that the resistance of the current measuring instrument, which is generally 4 ohms or greater, must not remain in the circuit. It must be shunted by a relatively low-resistance conductor, or wire. Many may fear that shunting the meter may cause difficulty because the distribution of the current between the meter and shunt will vary with the frequency. That is, the current through the meter will not bear the same relation to the current in the shunt at all frequencies. This would make it impossible to determine the current in the circuit.

But, where the actual values of the current are not needed, as in comparisons, and in the method referred to here, it will be found that the relation between the currents in the meter and shunt will remain the same, at the same frequency no matter what the total current in the circuit may be. In comparison measurements, therefore, no harm will come from shunting the meter if the comparison is made at a constant frequency.

As a result of this new information about losses in condensers, it should follow that a great part of the myriad radio fans will have to revise their ideas about "low-loss." The low-loss idea is a very good one, for it is upon the reduction of losses in radio circuits that efficient operation depends. It is about time, however, that the radio experimenter should learn that low-loss in a condenser does not necessarily mean metal end-plates. There are other factors to be considered, and it will be found that many of the metal end-plate condensers have higher resistances than some condensers with molded end-plates. It must not be forgotten that, if we assume other things to be equal, dielectric losses in molded end-plates decrease as the frequency increases (or as the wavelength decreases) while eddy-currents in metal end-plates increase. The effect of the end plates in either case is very small, so that it will be far better to concentrate our attention on the plates themselves, and forget the end-plates, except as a last refinement.

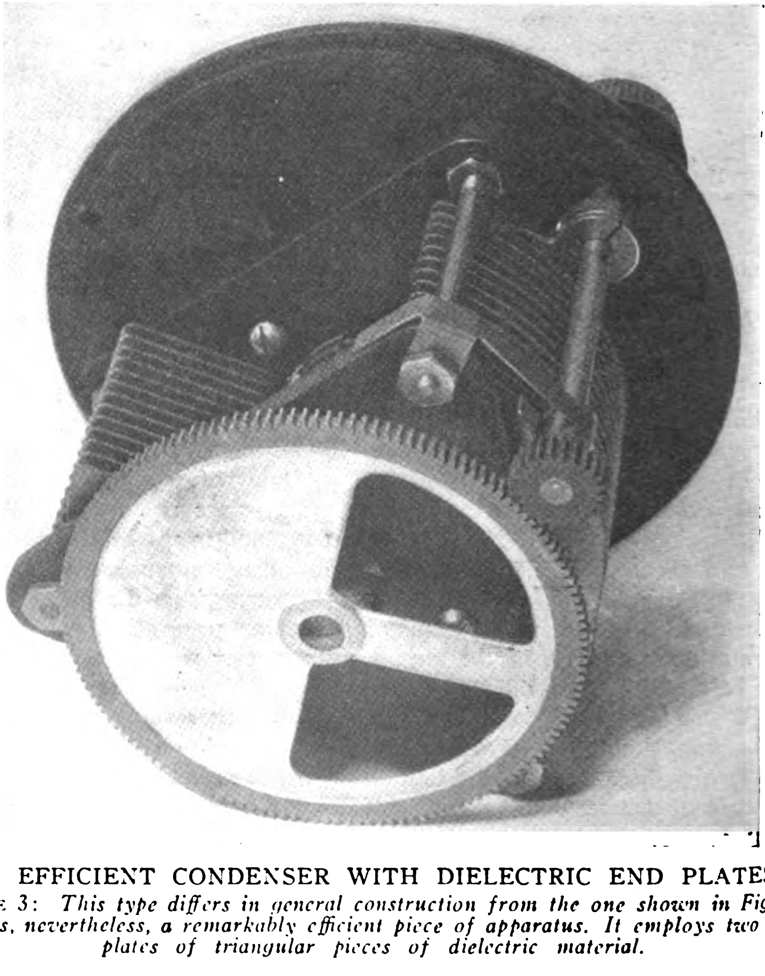
---

† Proceedings of the Institute of Radio Engineers, February, 1925.

Then too, the amateur should be cautioned against attempts to make comparisons of condensers when they are connected in actual tuning circuits.

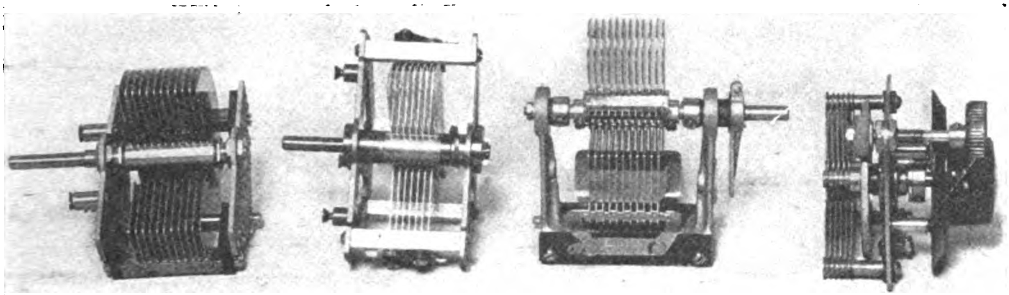
If one were to replace a relatively good condenser in his tuning circuit with one that is relatively poor, it is doubtful whether he could notice any difference in operation without exercising his imagination considerably.

The differences in the resistances of nearly all the condensers on the market are very slight. Furthermore, a change of say, a tenth of an ohm, more or less, in the resistance of the condenser means



AN EFFICIENT CONDENSER WITH DIELECTRIC END PLATES

FIGURE 3: *This type differs in general construction from the one shown in Figure 2; it is, nevertheless, a remarkably efficient piece of apparatus. It employs two end plates of triangular pieces of dielectric material.*



FOUR STANDARD MAKES OF VARIABLE CONDENSERS

FIGURE 4: *Here are some efficient makes of variable condensers—all of them, however, of different capacities. It is almost impossible to devise a means for testing and comparing condensers of different size capacities, as the physical dimensions as well as the capacity have a direct effect on the resistance at various frequencies.*

a change of only two percent in the total resistance of the tuning circuit, if we assume that the resistance of the coil is 5 ohms. The comparison generally shows up worse than this, for coil resistances often run up as high as 30 or 40 ohms. Another convincing argument has been found in the fact that the power output of the headphones has to increase ten times before the human ear can detect the increase. It becomes clear from this fact that the human ear can not be relied upon for such discriminations.

This recent study of condensers has brought to attention the following seven considerations, among others:

1: It is a fallacy to believe that all the losses in condensers are those in the dielectric material. Other causes of resistance are skin-effect in the plates, and eddy-current losses in metal end-plates and metallic structures.

2: Metal end-plates may introduce losses in condensers by reason of eddy-currents which may be in excess of dielectric losses in end-plates of insulating material.

3: In any event, the losses in the end-plates are only a small proportion of the total losses in the condenser. The greatest part of the loss lies in the plates themselves. This, of course, applies only at radio frequencies.

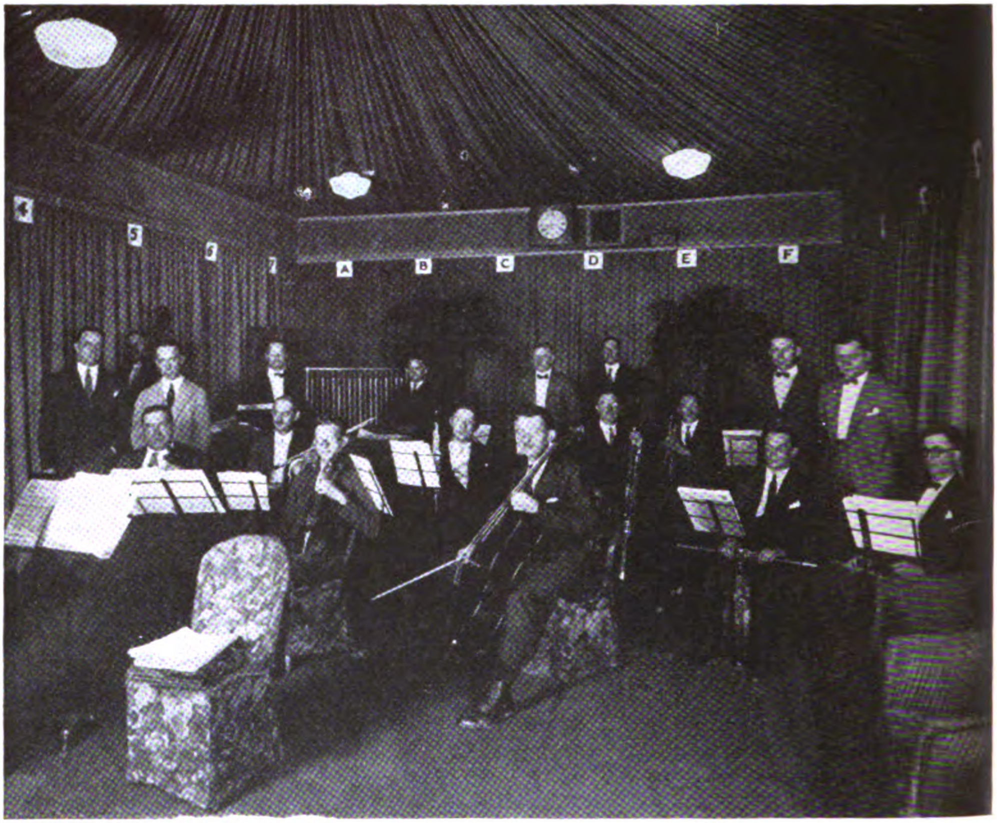
4: The argument is often advanced that a metal framework and metal end-plates reduce body capacity. This is true, but they do it by reducing efficiency and increasing losses. Body capacity in a well-designed, low-resistance receiver should not be troublesome.

5: The thinner the plates the less will be the skin-effect. Condenser plates should therefore be as thin as is consistent with mechanical strength.

6: The resistance of nearly all the condensers on the market is small compared with the resistances of the coils generally used with them in tuning circuits. As a rule the condenser losses represent less than ten percent of the total losses in the circuits.

7: Do not be misled by advertisements which represent the resistance of condensers to be zero or even as low as .1 or .01 ohm at radio frequencies. The lowest resistance in a commercial condenser now on the market is in the neighborhood of a half an ohm at 200 meters.

¶ *During the ensuing few months* POPULAR RADIO *will feature a series of articles on condensers—beginning with an article on straight-line-frequency condensers by Herbert J. Harries.*



From a photograph made for POPULAR RADIO

A MODERN AND SCIENTIFIC GROUPING OF THE INSTRUMENTS

The orchestra is placed at the opposite end of the studio from the microphone, and each instrument is located in the square (note how the squares are indicated by the letters and numerals on the walls) that tests have shown insure the best transmission in ensemble concerts.

"The Oboe in 4-D"

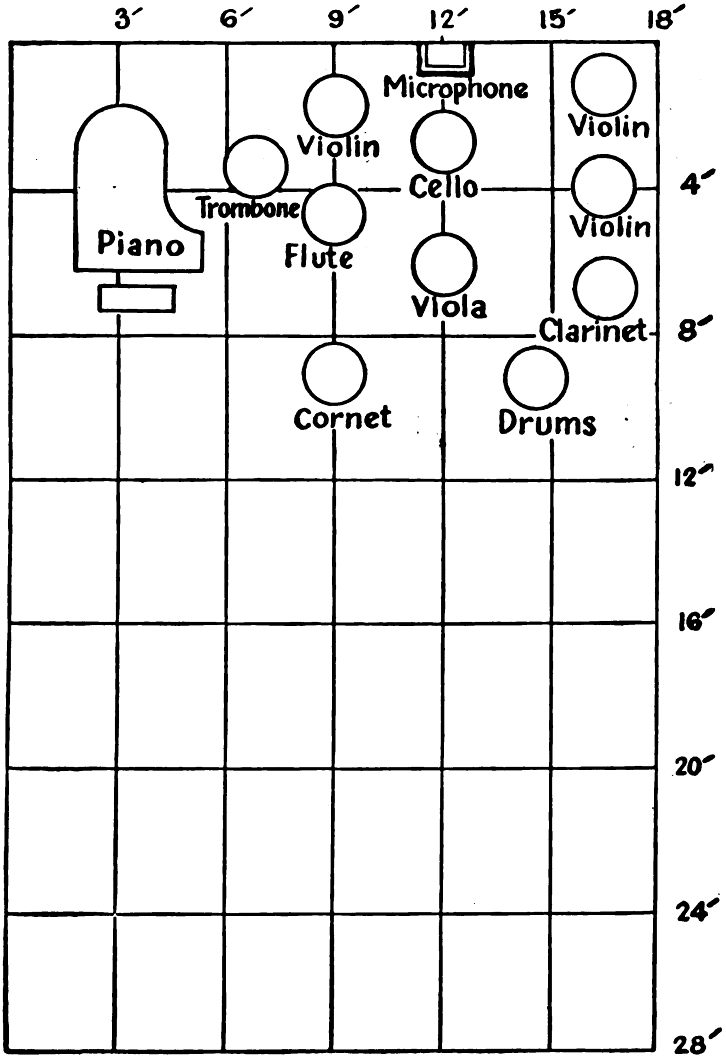
How science, which has vastly improved the transmitting circuit, is using the systems and charts of business for determining the exact locations before the microphone of each musician

By THOMAS L. BAYARD

WHILE the child is growing from a tiny baby of a few pounds to a strapping big boy of more than a hundred pounds, the mother, who sees him every day, is scarcely conscious of his increase in size from month to month, and realizes that he is growing rather by observing his change in moods and expressions than by making particular note of his increase in size. But the grandmother or the aunt who sees him only at intervals of three or four months, is quick to observe the change in size, and the increased dexterity with which he uses his body and powers of expression.

Most of the radio listeners are like the mother who lives with her child every day and who fails to note the weekly growth and improvement. After one acquires a radio set and gets a taste of the fascination of listening to the radio programs, he usually hears them more or less regularly; it is seldom that a confirmed fan will forsake his set for a time and turn a deaf ear to all radio programs for a long period of months. As a consequence he cannot readily compare today's program with the one three or six months ago, and he seldom realizes to the full the extent of improvement in radio transmission that is made in a year's time.

This improvement is strikingly revealed by two charts made by A. G. Popcke, an engineer attached to the staff of station KDKA, showing the proper position of orchestra instruments in a broadcasting studio now and two years



THE OLD "HUDDLE" METHOD OF GROUPING MUSICIANS

Because of imperfections in the transmitting circuit, which prevented much amplification of sound between the microphone and the transmitting set, the orchestra used to be crowded together—a system which gave improper tonal values to the various instruments. Compare this group with the one illustrated on page 530 ago. Mr. Popcke is a musician in addition to being an electrical engineer, and he checks the program daily to learn how different groupings of instruments affect the blending and tonal quality of the orchestra and band selections.

Two years ago the imperfections of the best transmission sets then in use made it necessary to group the orchestra instruments as close to the microphone as possible. The nearest instruments were two feet away, and the farthest often of necessity would be eight and ten feet away —four and five times the distance from the microphone to the nearest of the instruments. This made the nearest instruments sound much louder proportionately than the instruments farther away, as the strength with which a voice or musical instrument is recorded by a microphone diminishes very rapidly as the music moves away from the microphone. This wide difference in the strength registered by the various instruments threw out of balance the orchestral unity which had been developed by a long line of musicians through decades of study and practice in writing music scores for the orchestra.

It was realized that it would help some by placing nearest the microphone the instruments the tones of which possessed the least strength and carrying power, and Mr. Popcke set about to determine which these should be. He had been interested in this world's pioneer broadcasting station from its early days, when he had asked to pass on the talking machine records that were broadcast on some of the first programs and determine which ones would transmit well. Musical ensembles of which he was a member also had furnished music for some of the early programs.

As the result of his tests, the string instruments of the orchestra were placed nearest the microphone, the wood winds next, and the brass wind and percussion instruments farthest away. This order is still employed generally in the studios.

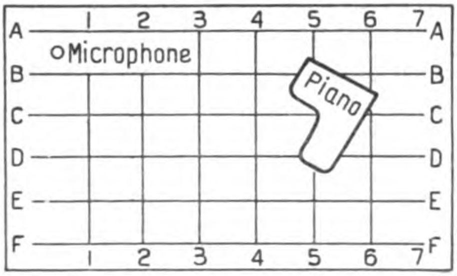
While proper arrangement helped some in regaining the desired balance for a band or orchestra, the results still were not entirely pleasing to the radio audience, which was constantly growing more and more critical of the radio program as the novelty of it began to wear off; people had begun to demand of the radio the degree of perfection asked in the other things they used every day.

The studio directors were prevented, by limitations of the early transmitting circuits, from moving the orchestra players back from the microphone and thus narrowing the difference between the nearest and the farthest instruments. The microphone of today gives off practically no noise, even when maximum practical amplification is applied, but those of the early broadcasting day, due to imperfections of the transmitting circuit, gave off a sputtering or "frying" noise. This noise was increased in volume as the tones were passed along the transmitting wires and through the vacuum tubes that amplified them before they were broadcast on the ether waves.

In order to keep down this "ground tone," as the engineers call it, and to prevent it from being broadcast with the music, the music was amplified as little as possible between the microphone and the antenna. To accomplish this, the radio people endeavored to have the musical tones strike the microphone with as much strength as possible, so that the volume of these tones would be considerably above that of the sputtering noise, and so that great amplification would not be necessary. This meant that the instruments were placed as close to the microphone as the players could conveniently sit.

As the transmitting circuit was refined, the sputtering noises were eliminated from the microphone and it became possible to increase greatly the amplification of the tones picked up by the microphone. This refinement has made such progress that today it is possible to group an orchestra from fifteen to thirty feet from a microphone, so that no in-

Distance From Microphone Desired	Location
4 Ft.	1½ B
5 "	1½ C
6 "	2 B
7 "	2 C
8 "	2½B
9 "	2½C
10 "	3 B
12 "	3½B
15 "	4½ A,B,C



Plan View of Studio

Distance of Various Positions From Microphone

Position	1	2	3	4	5	6	7
A	2½	6	10	14	18	22	26
B	2½	6	10	13	18	22	26
C	5	7	11	15	19	23	27
D	7½	9	13	16	20	23	27
E	—	12	15	19	21	25	28
F	—	15	17	21	23	26	29

Distance from Microphone (Feet)

Example: 2A = 6 Ft.
5D = 20 "
7C = 27 "

Vocal Selections		
Soprano	Distance	Location
Soft	5 Ft.	1½ C
Moderate	8 "	2½ B
Strong	12 "	3½ B
Contralto		
Soft	4 "	1½ B
Moderate	6 "	2 B
Strong	10 "	3 B
Tenor		
Soft	4 "	1½ B
Moderate	6 "	2 B
Strong	10 "	3 B
Baritone		
Soft	4 "	1½ B
Moderate	6 "	2 B
Strong	10 "	3 B
Bass		
Soft	2 "	1 B
Moderate	5 "	1½ C
Strong	8 "	2½ B
Male Quartet	10 "	Between 3A & 3C
Mixed "	10 "	

Instrumental Selections		
Instrument	Distance	Location
Violin		
Soft	5 Ft.	1½ C
Loud	10 "	3 B
Cello		
Flute	6 "	2 B
Soft	7 "	2 C
Loud	10 "	3 B
Clarinet	10 "	3 B
Saxaphone	12 "	3½B
Oboe	10 "	3 B
Bassoon	10 "	3 B
Cornet Trombone Horn	15 "	4½B
String Quartet		
1st. Violin	8 "	2½ B
2nd. "	9 "	2½ C
Viola	12 "	3½ B
Cello	13 "	3½ C

Orchestra		
Instrument	Distance	Location
First Violin	14 Ft	4 A
" "	" "	4 B
Second "	15 "	4½ B
Viola	15 "	4½ C
Cello	11 "	3 C
Bass Viol	8 "	2½ A
Oboe	15 "	4 D
Clarinet	19 "	4½ E
Bassoon	19 "	5 D
Flute	20 "	4 F
Cornet	24 "	6 E
Traps	22 "	6 C
Piano	20 "	5½ A
Small Band		
Clarinet	18 "	4 E
"	20 "	5 E
"	22 "	5 F
"	24 "	6 E
Oboe	20 "	5 D
Bassoon	18 "	5 C
Flute	20 "	4 F
Cornet	28 "	7 F
"	25 "	6 F
French Horn	22 "	6 C
" "	25 "	6½ C
Baritone	26 "	7 B
Tuba	23 "	6 D
Traps	22 "	6 B

Note: For above Piano at 5½ A as in Plan View of Studio.

Guide for Placing Soloists & Ensemble Combinations In Studio

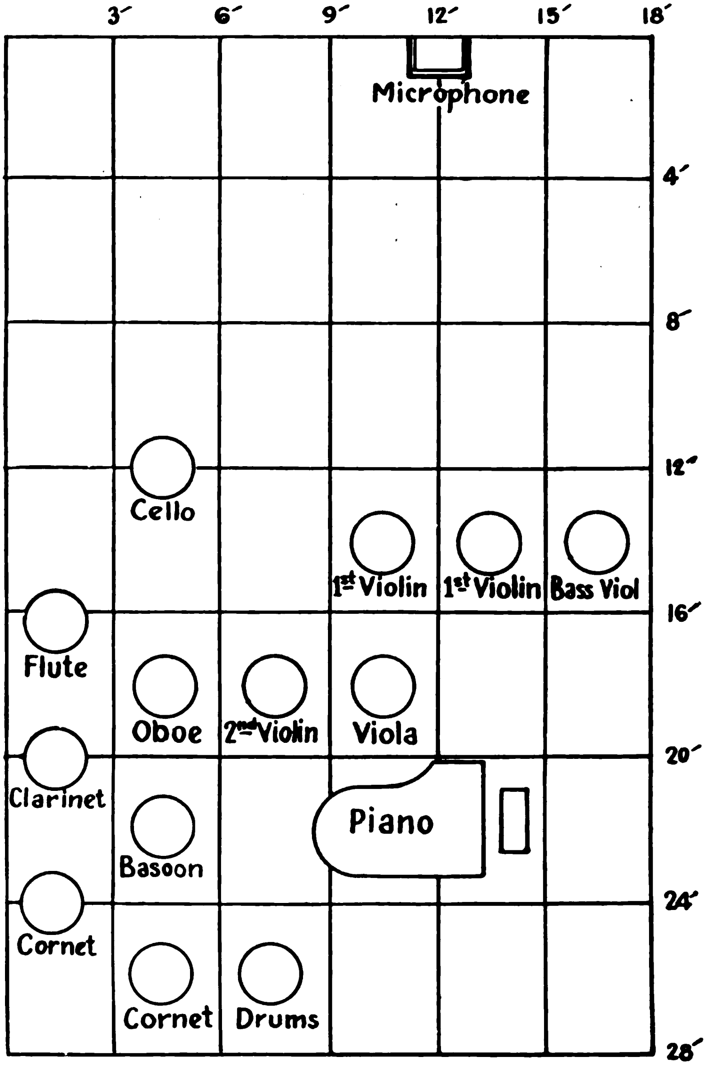
HOW THE ARRANGEMENT OF THE PLAYERS HAS BEEN REDUCED TO A SYSTEM

Just where each soloist or each musician in an ensemble combination should be located in relation to the microphone has been reduced to the formula expressed in this chart, which has been designed for the practical guidance of the studio manager. The exact position of the oboe player in an orchestra, for example, is shown to be 4-D; of the cornet, 6-E. The distance figures show the tendency to move all artists away from the microphone.

strument is more than twice as far from the microphone as another.

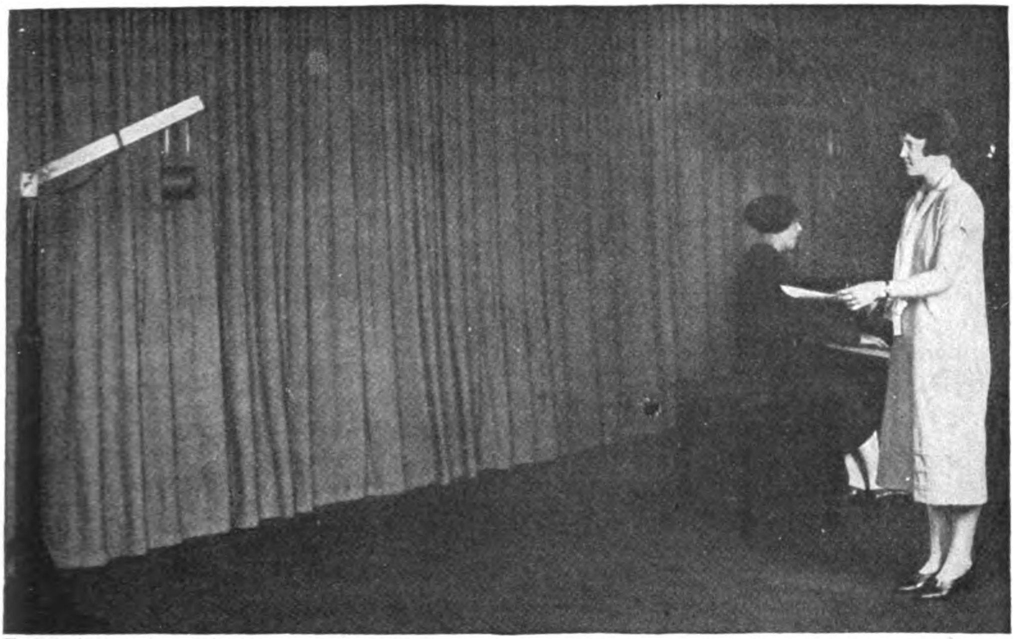
In the charts shown on page 527 and below on this page, made by Mr. Popcke, the one used two years ago to indicate the proper positions of the orchestra instruments shows all the instruments huddled together in a third of the studio nearest the microphone, while the chart that shows present positions shows the instruments grouped in the half of the studio farthest from the microphone.

The floor at the KDKA studio from which most of the musical programs are broadcast is divided into imaginary squares three feet wide and four feet deep, this being the usual amount of space required for each musician. The squares are indicated by letters placed during certain programs on two opposite walls and numbers placed on the other two walls of the studio. The instru-



THE MODERN SYSTEM OF GROUPING THE MUSICIANS

Note that the microphone is at one end of the studio and the orchestra is scattered about the far end. This arrangement is now possible because of the improvements made in the transmitting circuit, which permits the sound to be greatly amplified without loss of quality.



From a photograph made for POPULAR RADIO

THE DISTANCE FROM THE MICROPHONE DETERMINES THE QUALITY OF TRANSMISSION OF SINGING

The position of the singer before the microphone varies with the power and quality of the voice; a soprano with a strong voice may stand ten or twelve feet away, and the piano may be as much farther away as necessary to attain a proper balance.

ments are moved from one square to another between programs, and sometimes between selections of the same program, to see just which locations are giving the best tone effects.

In one of the Westinghouse Saturday night band programs (which are relayed in London by the station's international short wave relay system), it was found that on the first selection the tuba was too loud for the rest of the instruments. The tuba was about seventeen feet from the microphone, while the instruments nearest the microphone, the first clarinets, oboe and bassoon, were fifteen or sixteen feet distant. In playing later selections the tuba was moved back to the twenty-four foot position, and as it still was somewhat too loud for proper blending of the band instruments, the bell of the instrument finally was turned away from the microphone before the desired results were obtained.

During this program, the cornets and baritone were in the square twenty-four feet from the microphone, while the second clarinets, flute, drums and horns were situated between the nearest instruments and the brasses in the rear. The drums were placed well up towards the front row, because much of the band music is rhythmic and requires that the sounds of the drums be prominent to give it proper effect. This in general is the arrangement used in the KDKA studios.

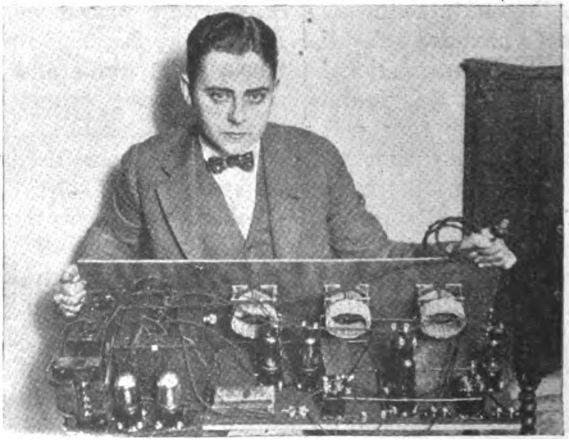
When orchestra music is broadcast, the violins and cellos are placed nearest the microphone, with the oboe, clarinets, flute and the bass next, and the cornets and drums in the rear.

The arrangement is varied, however, as some selections will require that the cornets or drums be as close to the microphone as are the string instruments. When a string or wood wind instrument has a solo part, the player moves to a point between the microphone and the front row of players, when possible to do so without causing too much confusion in the studio. The brass instruments with their greater penetration are usually heard well in solo parts when they remain in place. Sometimes, however, the brass instruments must be moved closer to the microphone, as when "The Lost Chord" is played as a cornet solo. In this selection, there is a full harmony swelling to a climax at the end which sometimes buries the cornet part unless the cornetist takes advantage of position and moves between band and microphone. "The Rosary" is another selection of the same kind. In a selection like Schubert's "Serenade," however, the accompaniment is less prominent and no change in the cornet soloist's position is necessary.

The distance a singer should stand from the microphone depends upon the strength and pitch of the voice. In general a bass or baritone should stand nearer the microphone than other singers, as the lower vibrations of the bass voice do not make the same impressions on the microphone as are made by the higher vibrations of the other types of voices. The contralto voice may usually be placed farther from the microphone than the bass, the tenor next and the soprano farthest away. Actual strength of voice must also be considered.

Not all sopranos, however, should stand exactly the same distance from the microphone, nor at the same position in relation to the piano. In general, the piano for solo work should be placed fifteen to twenty feet, with the piano opened. For vocal solos the orchestra, when orchestra accompaniment is used, is placed at its usual position, with the singer ten to fifteen feet, depending on the type and strength of voice. When piano accompaniment is used, the piano is usually placed at a distance of fifteen feet.

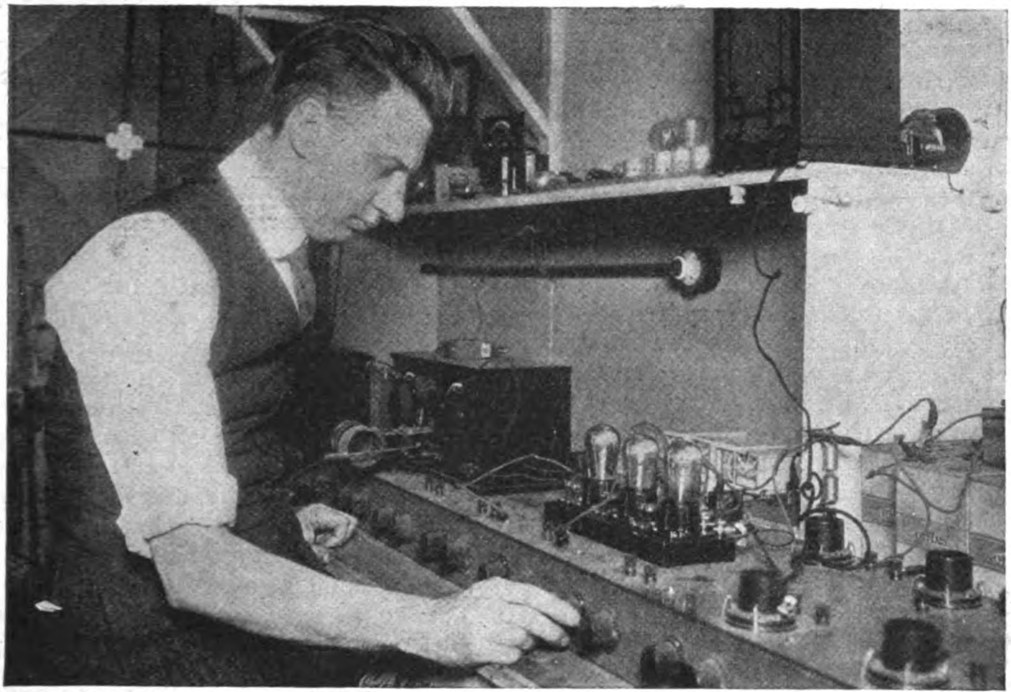
Mr. Popcke has worked out a guide for the studio directors to use in placing soloists and ensemble combinations during the broadcasting. This guide shows the floor plan of the studio, and also a chart that gives the exact distance of the various positions, 4-B, 6-C, and so on, from the microphone. Tables that give the approximate location for the various type of voices and instruments, both in solo work and orchestra or band selections, are included.



Kadel & Herbert

A SET THAT OPERATES ON 110 VOLTS AC

A five-tube set that uses no batteries is the accomplishment of Rutledge Mayo of New York, in this receiver equipped with McCullough AC vacuum tubes. A small step-down transformer supplies current to the heaters which replace the ordinary filaments, while a two-tube rectifier supplies the plate voltage.



From a photograph made for POPULAR RADIO

A STRAIGHTLINE-FREQUENCY AUDIO AMPLIFIER

The resistance-coupled amplifier (such as pictured above in a laboratory set-up) should amplify all frequencies alike without choice—if it is properly designed. This type of amplifier is one of the popular types now in use by fans and experimenters for obtaining musical quality.

"Truthful Reproduction"

How to Get It from Your Set

Practical pointers for radio fans who want to know what causes the faults in radio reception and how to get rid of them

By PAUL GODLEY

THE equipment in all of the major broadcasting stations of the country and in most of the minor stations, has been designed and installed by large manufacturing organizations who have a considerable staff of carefully selected engineers. These men are constantly busy in an effort to improve the quality of transmission. In the case of the major stations—those stations about which we read the most and to which we listen the most—new developments are being continually put to work, with the result that a tremendous improvement in quality, shading and expression has been brought about in a comparatively short period of time. As compared to the state of affairs a year ago, practice in these stations is rapidly approaching perfection.

It must be apparent to anyone that to make this improvement at the broadcasting station fully effective it is also necessary to insure that the detecting, amplifying and reproducing equipment of the receiving set, in the home, is capable of delivering sounds which have not been slighted, distorted or which have lost their original studio values.

It is a regrettable fact that practically none of the equipment offered to the American public during the season of 1924-5 fulfills these requirements. As a matter of fact, of the one hundred and thirty or more nationally known manufacturers of radio receiving equipment over one hundred may be tabulated as offering equipment wherein the amplifying units at least were patterned after designs developed during the World War period for the reception of radio dot and dash signals. On this account at least, it is unfortunate that the method of reproducing radio-telegraphic and radio-telephonic signals is so nearly identical.

The marvel of taking vocal and musical sounds right out of the air has, of course, been the big thing in the minds of the public—has been the thing which has created tremendous markets for radio equipment. These markets in turn have tempted the manufacturer to put off just a little while longer the refinements with which his receiving equipment must eventually be supplied. To become permanent, radio must become *truly* musical.

In reviewing the development of the last four years the most surprising thing encountered is that up until the past summer only four or five manufacturers seem to have grasped the importance of this fact.

In order that the high-class modulation of the present day may be reproduced at the receiving end with complete success the receiving equipment must properly perform three functions:

(1) *Detection;* wherein the radio "carrier wave" is rectified so as to leave in the "out-put" circuit of the detector pulsating currents capable of transformation into sound.

(2) *Amplification;* wherein the sound currents are enlarged to the point where sufficient power is available for the operation of a loudspeaker.

(3) *Reproduction;* wherein the electrical energy in the form of sound currents is transformed in the speaker into mechanical energy thus producing sound waves in the air.

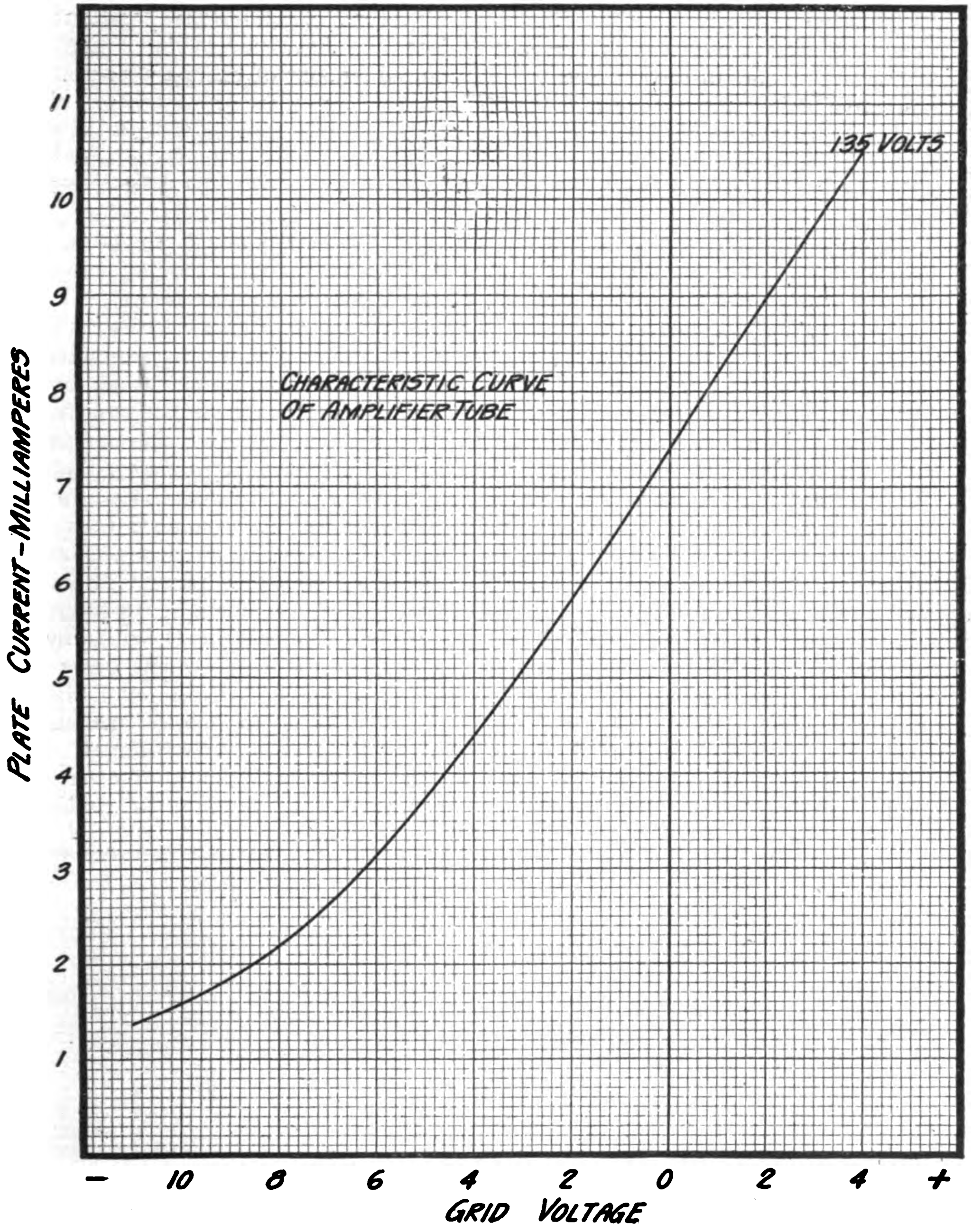
The requirements of detection are not difficult to supply. Perhaps the most common cause of fault in the detector circuit is that of a noisy grid-leak.

The grid-leak is used by manufacturers universally. It consists of a very small unit of high resistance—two to five million ohms. Generally, it is constructed by coating a tiny piece of hot-pressed card with a delicate layer of carbon or graphite in liquid form. The delicacy of the device is such that, too often, changes in temperature and humidity subject it to abuse. Eventually the carbon film upon the card is partially ruptured, whereupon the resistance of the unit is continually changing. The result is a continual change of current flow in the input circuit of the detector and certain scratching or hissing sounds not unlike the scratch of a phonograph needle. The ready cure is the substitution of another grid-leak which may or may not continue to function indefinitely.

The proper cure for trouble of this character is the use of a grid-leak that is now coming into the market, and which has a very finely drawn filament of carbon and which should remain constant once and for all.

In regenerative receivers detector action is frequently distorted by the operation of the receiver circuits too near to the unstable condition. Proper adjustment is, of course, possible, but an unsatisfactory adjustment is so easily secured by the novice that receivers wherein a control over the regeneration is provided have come into disfavor.

Various types of receivers utilizing what may be called "controlled" regeneration together with amplification of the signal prior to detection have replaced the



THE STATIC CHARACTERISTICS OF AN AMPLIFIER TUBE

This chart shows the change in plate current, in a vacuum tube when used as an amplifier, corresponding to varying grid voltages, for a given plate voltage of 135 volts. Amplifier tubes work best along the straight portion of the curve, but the free grid potential must be kept slightly negative so that the incoming impulses will not swing too far in a positive direction and cause overloading and distortion.

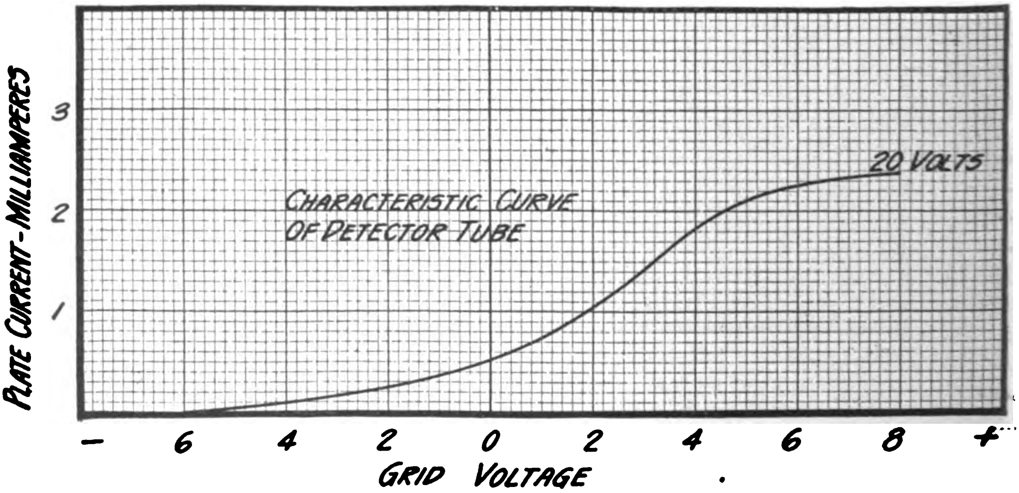
regenerative receiver. If the automatic control of regeneration has been carefully worked out, distortion due to regenerative action prior to and during detection is usually negligible. However, another difficulty which mainly concerns the reception of good music from near-by stations creeps in, i.e: the overloading of the detector with its consequent distortion.

A moment's study of the characteristic curve of a three-element vacuum tube detector will serve to illuminate this point.

The wide variation in voltages which may be supplied to the grid of a detector tube by the radio amplifier tubes runs operation over into the flat portions of the curve. A uniform variation of plate current for variation of grid voltage cannot take place under these circumstances, and a muddled flatness of all tones results. Here, some sort of control over signal volume prior to amplification and detection is the obvious requirement. In antenna types of receivers a variable coupling transformer inserted between the antenna and radio amplifier tubes serves the purpose. In loop type receivers, the position of the loop may be varied to determine the required amount of energy pick-up. Lacking either of these arrangements, the only recourse is to utilize a very small antenna for local reception in order that the detector tube may not be overloaded.

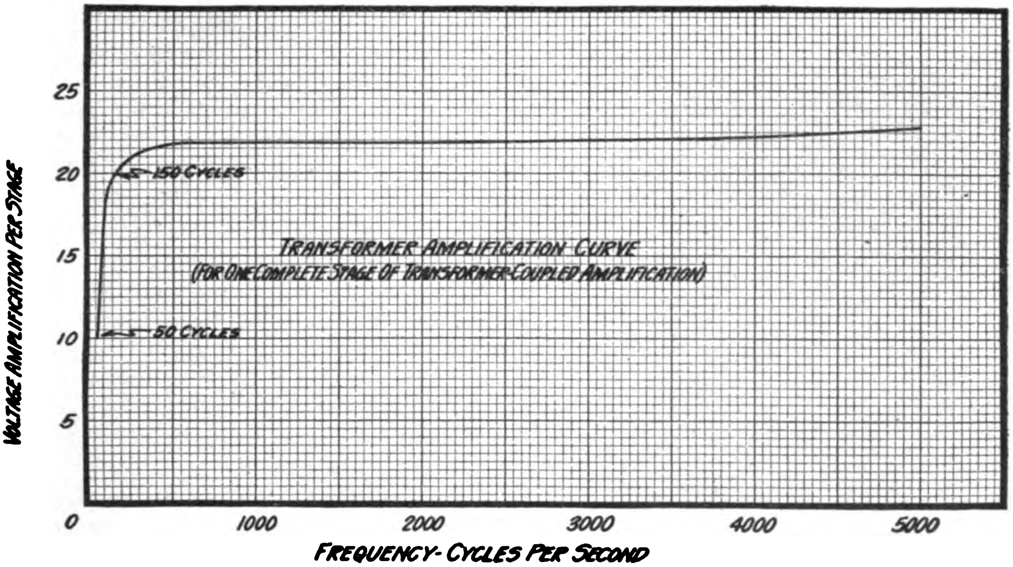
That portion of a radio receiver known as the audio amplifier is made up of (1) the amplifier tubes and (2) the inter-tube voltage-step-up transformers together with appropriate circuits.

In present practice the amplifier tubes differ in no essential particular from the detector tubes. The tubes now supplied perform one function as well as the other in properly arranged circuits. If the tube is that type that has the thoriated filament, it is subject to a failing which has at once puzzled and annoyed thousands of radio fans. These tubes usually have a filament of tungsten which has been impregnated with thorium. Thorium is a metal which gives up its electrons freely. When the filaments are burned at too great brilliancy, or when the plate battery voltages are carried too high, the supply of electrons inherent to the thorium is rapidly ex-



THE STATIC CURVE FOR A DETECTOR TUBE

This chart gives the change in plate current for variations in grid voltage of a detector tube, when used with 20 volts of plate battery. The detector operates efficiently when the lower bend of the curve is utilized for rectification because the positive voltages produce larger changes in current than the negative swing. In fact, this is the method used for obtaining rectification.



THE CURVE FOR VOLTAGE AMPLIFICATION AT VARIOUS FREQUENCIES

This chart shows the steep cut-off in amplification at low frequencies. Notice that the curve is practically a straight line from 500 cycles to 5,000 cycles per second, but at 150 cycles the amplification has decreased by roughly 10 percent. At 50 cycles the amplification has decreased to less than 50 percent of the amplification at 1,000 cycles. This means that tones below 150 cycles are not amplified to the same strength as those of 500 cycles or more. In this way, the low tones are missed in the music that is produced. The curve shown is for a transformer that is slightly below the average of those produced today. A few transformers now on the market have a much better low-frequency curve than that shown here.

hausted and the tube becomes a "dud."

It is the rule to find one or more "duds" in a receiving set which has been in operation a few weeks. A lowering of the emission of the filament results in tone souring.

Radio receivers wherein grid biasing batteries (known as C batteries) are connected are found to give the least trouble on this account. The loss of emission on the part of the tube is more often than not caused by the burning of the tube filament at too great brilliancy. If no filament voltage meter is built into the set it is best to operate the tubes somewhat below that point where maximum response is had than on or above that point.

"Dud" tubes may be reactified by the proper treatment. However, so many novices have destroyed tubes in an attempt at reactivation that no account of the method will be given. Nearly every dealer in radio supplies has, or should have, equipment designed especially for this work, and is generally glad to perform the service at a trifling cost.

By far the greatest shortcoming of the radio receiver with respect to true tone reproduction is apt to lie in its lack of inter-tube transformers having what is known as straight-line frequency characteristics—a transformer which is capable of handling in exactly the same manner tone currents of every frequency within the musical scale. If quality of tone is desired particular attention should be given to this point, either in the selection of the complete receiver or in the selection of the audio transformers for a receiver under construction.

Nearly all the transformers offered up until the past summer have been so designed as to seriously slight tones that begin at an octave below middle C on the musical scale, while in many cases no sign of operation on tones two octaves below middle C is apparent. This re-

A TRANSFORMER THAT AMPLIFIES LOW TONES AS WELL AS HIGH TONES

A receiver should incorporate in it one of the more modern makes of transformers, of rather large size, so that more amplification will be obtained at the lower frequencies. This will result in more "life-like" reproduction.

sults in the tin-pan music so closely identified with radio in the minds of many people. A musical rendition is seldom properly rounded out when it is lacking in the base tones, and certain it is that lacking them, the reproduction of America's most famous organ sounds for all the world like an accordion.

It is the habit of manufacturers of amplifier transformers to publish curves showing the amplification characteristics of their transformers. With perhaps one exception these determinations have not given any information with respect to tones more than ten full notes below middle C. The assumption is that suitable equipment for measurements at the lower frequencies has not been available to them. In any case, reliable information has heretofore been lacking, and unscrupulous manufacturers have been known to "fake" transformer curves for the lower tones. Transformer designs to accommodate the low tones as readily as the higher ones call for large values of inductance in the primary windings—thirty-five henrys and upwards. The average of the past is less than one third this figure. Large primary inductance values mean a larger number of primary turns, or a larger amount of the proper grade of core iron, or both. This may mean a larger transformer throughout, the developments of some of the larger electrical companies in the way of special steels show promise of securing transformers with the required characteristics of a size even smaller than those used at present. The practice of "doctoring" an audio amplifier circuit with condensers and resistances across primary and secondary of the transformers in order to secure a sweetening of the tone is a poor subterfuge to be guarded against in selecting or constructing the receiver.

Set builders in the past have been much puzzled concerning the proper ratio of primary turns to secondary turns in the transformer. Carefully designed transformers seem to indicate that a ratio of 3.5 to 1 insures the most satisfactory all-around results, and manufacturers have come to accept this as standard. This does not mean that all transformers having this ratio possess good characteristics. The safe procedure lies in the careful scrutiny of transformer specifications. If they are in the least hazy concerning tones below one hundred cycles, look elsewhere.

Because of a rapidly growing demand for full-toned reproduction, what is commonly known as the resistance-coupled amplifier circuit has become very popular with set builders during the past season. Regardless of tone frequency the resistance-coupled amplifier shows uniform action. It possesses true straight-line frequency characteristics. It has not been adopted by set manufacturers because of certain inherent disadvantages. The amplification per tube is not as great, as it is usually necessary to use three tubes to secure the same tone volume as may be secured with two where transformer-coupled circuits are used. Also, higher values of plate voltage are required. On the other hand the quality of tone which it provides leaves little to be desired and on this account it can be highly recommended.

With radio listeners it is the all too common practice to try for the greatest possible volume of tone from the radio set, and receivers as manufactured show a marked decrease in the quality of tone when put through such exercises. Perhaps this is due mainly to the unsatisfactory characteristics of the average inter-tube transformer, but it has been observed that in a great number of cases the difficulty arises through another cause. Reference to the characteristic curve of a tube such as used in the amplifiers at the transmitter will show that changes in the current of the plate circuit are approximately directly proportional to the changes in grid voltage. On the other hand, the curve of the detector tube shows that variation in plate current is approximately as the square of grid voltage variation.

Thus, when the volume of tone is double in the transmitter studio the modulation of the transmitter and the voltages at the receiver are doubled. With a doubling of the voltages on the grid of the detector tube there comes, however, a quadrupling of current change in the plate circuit of the detector. This brings about a great increase in the loads thrown upon the amplifier circuits.

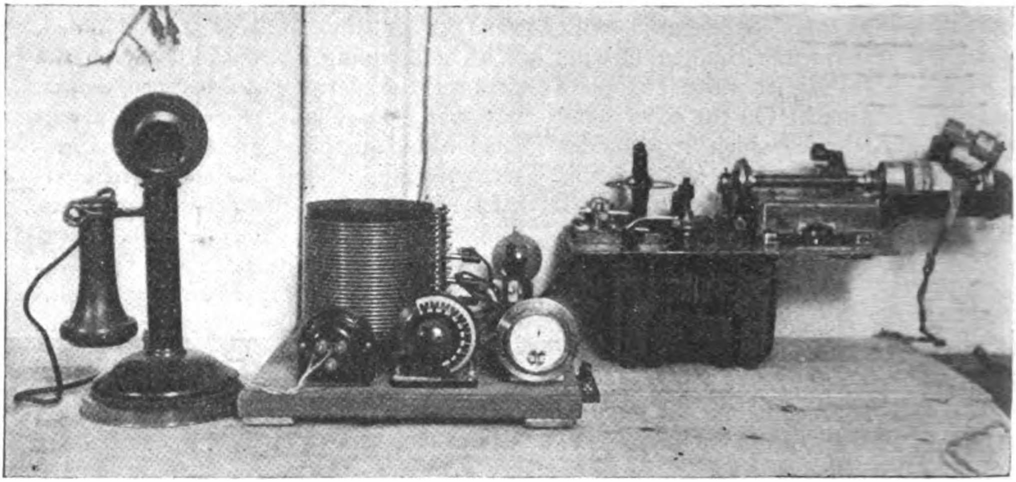
Upon attempting to produce great volume with the ordinary receiver considerable overloading with its consequent flattening of tone results. This is an experience which owners of dry-cell tube sets may expect to encounter frequently. With such sets tubes of larger capacity are required in the second stage of the amplifier. Regardless of the type of set or tube, where greater than moderate volume of tone is required tubes of larger capacity will have to be used if tonal quality is to be preserved. Accommodation for such may either be built into the set, or a special amplifier may be annexed to the receiver.

(To insure that one's receiver is capable of producing real music requires precaution. Thought given to the matter cannot but prove of lasting satisfaction. Of course, having seen to the capabilities of the receiver, one could scarce afford to make an unsatisfactory choice of the loudspeaker. It may be selected by actual comparison when connected to the favorite receiver, but even in this way many have been led astray. For these reasons a discussion of the characteristics of various types of reproducers by Mr. Godley will appear in a forthcoming issue.)

—Editor

Pacific & Atlantic

Bartholomew Molinairi of San Francisco (6AWT), is the first radio amateur in this country to communicate with French Indo-China. His signals have been heard in nearly every quarter of the globe.



This method sends photographs over an ordinary, commercial telephone line, without physical attachments to the instrument. The complete receiver is shown above; the cylinder with the received photograph is visible at the right.

A NEW METHOD OF TRANSMITTING

Pictures by Telephone—or Radio

One of the most important uses of the new instrument, the photo-electric cell—described in POPULAR RADIO last month—is in the transmission of photographs or other pictures by radio or by land wire. The new Phono-Photo method for accomplishing this involves several new principles. It is described in this article.

BY EDMUND H. HANSEN

DURING the past two or three years the newspapers as well as the magazines have called attention to the different methods of photo transmission and the great strides that have been made in the development of "pictures by radio." While to a large extent the developments of even such early experimenters as Korn and Belin are antedated by others, the fact remains that, like Marconi, the commercial application has followed their efforts. Until such a time as development warrants common usage, the transmission of both photographs and television will be of but momentary concern to the general public.

To be commercially practical the transmitting and receiving apparatus requires a ruggedness in construction and a simplicity in operation. This is best exemplified by the telephone, which is a machine capable of handling the most minute electrical currents and constructed to stand the rough handling and abuse of everyone. It was with these virtues in view that the phono-photo method of transmitting pictures was developed over two years ago. The fact that one of the best known methods has adapted certain of its features for its own is the biggest recommendation of its merit.

In all the methods that are being applied commercially today there are three major operations performed.

First, the conversion of the light values of the photograph into electricity; second, the transmission of these impulses, and third, the conversion of the electrical impulses back into light so that a record may be properly made.

The first and second operations are practically distortionless in all methods, and it is mainly in the third that sufficient distortion occurs to prevent accurate reproduction.

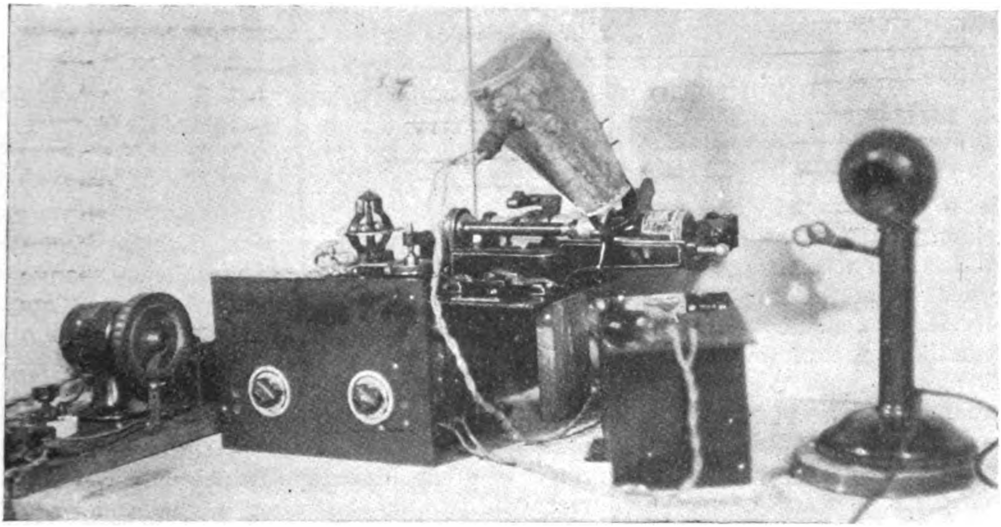
Unlike audible reproduction the eye demands one hundred percent efficiency and is not satisfied with less. In radio broadcasting slight static and extraneous noises are passed unnoticed, but in the transmission of photographs all flaws and blemishes form a permanent record. In converting electricity back into light either electro-mechanical or electro-chemical means are employed.

In the electro-mechanical methods, the Blondell oscillograph of the Belin method, the light valve of the American Telephone and Telegraph Company and the pneumatic oscillograph of C. Francis Jenkins are the better known. The Telepix method is the only one that uses electro-chemical means of conversion in commercial use today. It is a well known law of physics that in the operation of conversion certain losses take place, and the simplifying of any function by eliminating these losses will tend to a more perfect machine.

In the phono-photo method of telophotography there are only two operations; the conversion of light into electricity, and the transmission thereof.

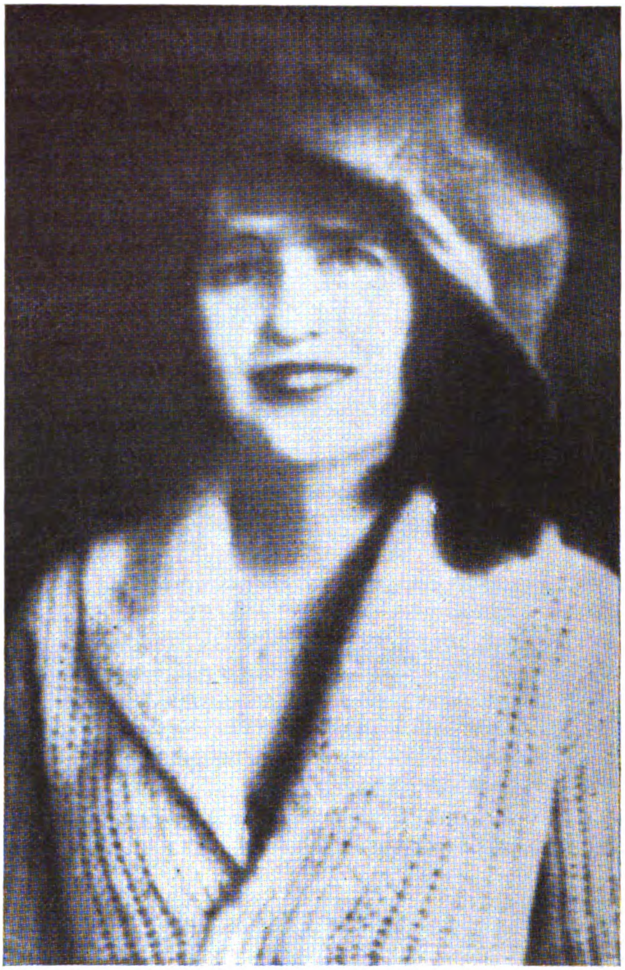
For recording, special, gas-filled tubes are utilized. The received current flows in these tubes, which give varying actinic values for reproduction. Two types are used; in one there is an actual change in the quantity of the light, and in the second a light of varying spectrum value is obtained. In short, the wavelength of the light varies as the frequency of the incoming picture signal. As recording film is made for its greatest sensitivity at the white a change from white to red would be the same as varying a quantity of white light.

In the circuit used for wire work it will be seen that a constant frequency is ordinarily employed, although both varying and constant-frequency methods can be used for radio and wire trans-



THE COMPLETE TRANSMITTING APPARATUS

A moving light-pencil passes over the picture to be transmitted and is reflected into a photoelectric cell. The current from this varies with the intensity of the light reflected, thus corresponding to the lights and shades of the picture.



TRANSMITTED BY THE PHONO-PHOTO METHOD

The intensity of the light-ray emitted by the receiver is varied by the electric signals sent over the wire, thus producing varied light and shade on the sensitive photographic film. A photograph of this size can be sent and received in less than two minutes, less than the time of a long-distance call.

mission. This constant frequency is modulated in accordance with the varying density of the film by means of a photoelectric cell. There are two different methods of exploring; both film and flat plates may be analyzed. The flexible film is wrapped around a glass cylinder which is rotated and a spiral forward movement results. In working from a flat surface a special mirror mounting is used for the lateral movement and the plate is moved up or down at a synchronous interval a small fraction of an inch.

The photoelectric cell is of a special type and is capable of a frequency change of ten thousand per second. This permits transmission of a 5 by 7 inch photograph in two minutes or less. This is approximately four times as fast as any other known method. Working directly from the negative is of great advantage in newspaper work. In two of the other methods now in use, from two to four hours are required for the preparation of special transmitting cylinders.

In transmitting the picture, consideration is given to the type of communication available. In the case of radio, the varying frequency has been found most desirable as this permits the same efficiency of the transmitter as when emitting straight C. W. telegraphic signals. In this case a special transformer circuit varies the frequency of a master oscillator which in turn controls and varies in a similar manner the output of the power amplifier tubes. The transmitter is therefore varying its frequency in accordance with the different light values of the negative. As the mode of transmission is merely one dependent upon frequency alone the usual fading or swinging of signal strength does not mar the picture received.

As already stated, the usual wire method employs a single frequency which is modulated by the photo-electric cell. It has been found desirable to utilize standard telephone circuits without a physical attachment to either instruments or lines and placing upon those lines merely sounds of usual intensity and pitch as of that of the human voice. This is accomplished by means of a special loudspeaker which talks a picture talk instead of the usual audible languages into the telephone microphone. This passes over the lines in a regular manner and as in radio the results being dependent upon frequency alone, the varying signal strength of the line does not change the reproduction of the picture.

AN ORDINARY TELEPHONE LINE MAY BE USED

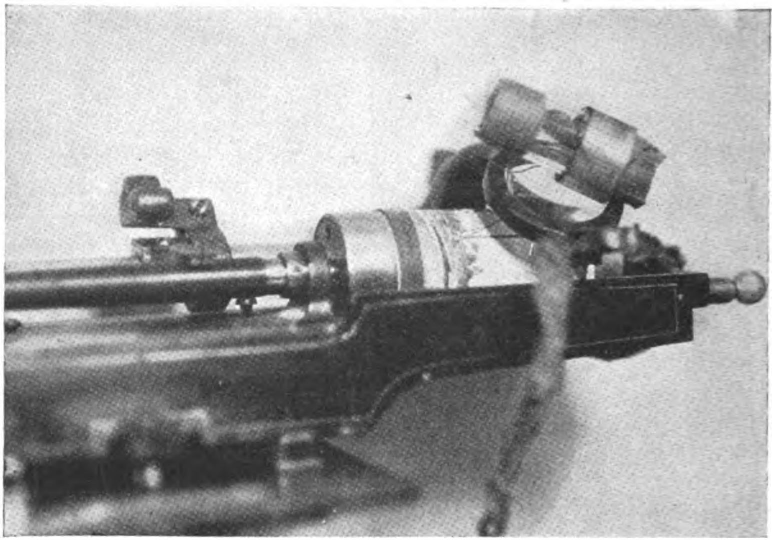
A special diaphragm conveys the picture-message to the telephone instrument. The message is transmitted just as a sound would be.

In receiving, a special microphone is actuated by the air waves from the telephone receiver, and this is passed on to the glow tube circuit which performs two functions; that of modulation and that of amplification.

The amplification is accomplished without cascade tubes. In the use of varying frequency a glow tube is used that changes the frequency of the light with the impressed electrical frequency. As there are no moving mechanical parts or chemical reaction, this method is without distortion and is capable of unlimited speed in producing light changes. The constant frequency method merely varies the quantity of light emitted by the glow tube. This takes place over one of two buttons placed inside the tube. In both cases the light is condensed by lenses to a pin point and is photographed upon flat plates or film negatives.

The synchronizing or timing of the transmitter and receiver is accomplished by independent "time beaters" at each station which control, through a local circuit, their respective machines by means of magnetic clutches. This insures much smoother operation than that accomplished by the usual slip clutch, and gives a steady motion. This independent method is equally applicable to radio and wire and requires no special channel or impulse for correction purpose.

The necessity for simplicity and ruggedness is apparent from inventions in every day use, and the accomplishment of this in this method will undoubtedly



THE GLOW LAMP AT THE RECEIVING END

The frequency of the light emitted by this lamp varies in accordance with the electric signal being received. The light-spot from the lamp is focussed on the sensitive photographic film by a lens. The film-covered cylinder rotates in exact time with the cylinder at the sending station, thus reproducing the picture.

go a long way to popularize the transmission of visual messages. Heretofore, great difficulty has been met in obtaining transmission service. With this system your desk telephone in New York, when connected to one in San Francisco, will transmit a five by seven photograph within the minimum toll-time limit of three minutes. This use of the telephone wires does not violate the contract clause against attaching additional instruments to your telephone. The sound waves of this system are the same as the human voice except for the language. This is further proven by the fact that similar to our conversation which remains intelligible even though the strength varies a picture will be received even though similarily interfered with. Both are based upon frequency combinations rather than change in amplitude of vibration.

With the increased efficiency of short waves and the fact that this method employs a standard type of telegraphic transmitter, business and private interests can control their own communication medium. Machines for this system can be made for $500, and quantity production should lower this price still further. This would permit all business firms to own and operate their own machines.

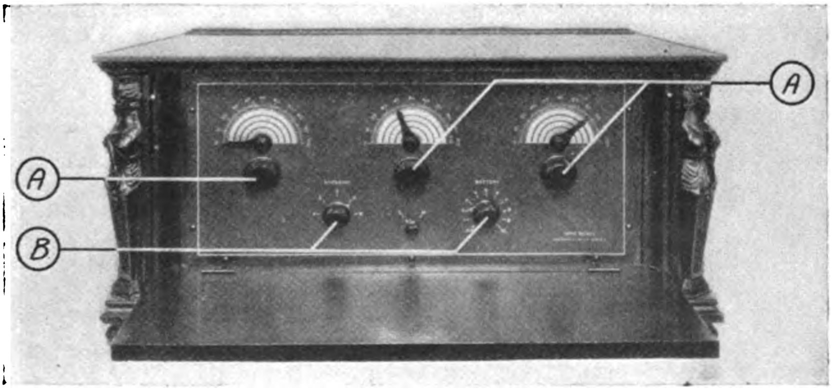
When using standard plates and film for transmission and reception no special preparations are necessary before transmitting. In fact, the corner drug store can do the photographic work for you while the local radio store would be sufficient to maintain the electrical equipment in good order. This will remove the transmission of pictures from the hands of research engineers and place it in the keeping of those to whom all inventions belong—everybody.

When Your Set Won't Work

WHERE *to start looking for the trouble; how to check up on the connections; how to locate and determine the nature of the disturbance—will be told, for the particular benefit of non-technical broadcast listeners, in* POPULAR RADIO *for January.*

"What Set Shall I Buy?"

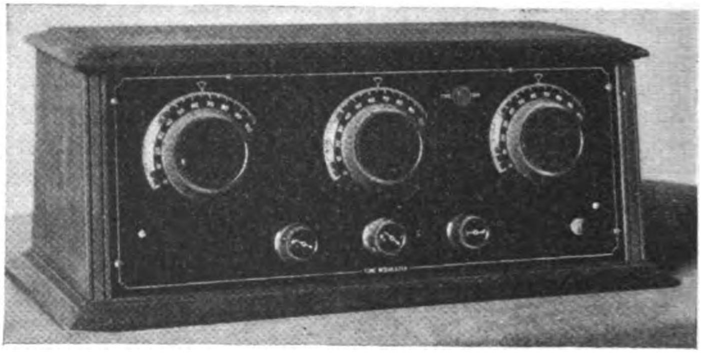
LESS then a year ago there were only a very few ready-made sets on the market; today there are about 140, ranging from small and inexpensive crystal receivers, which sell for as low as four or five dollars, to elaborate superheterodynes that run into the hundreds. Those that have been approved by the Popular Radio Laboratory will be pictured each month until the series is completed. They will be accompanied by brief but specific data concerning them—as a helpful guide to the broadcast listener and to the prospective listener who is thinking of selecting the receiver that will best meet his special needs as well as the limitations imposed by his purse. The data following each of the sets pictured in this series are the manufacturers own specifications and claims; they were obtained through a form of questionnaire sent to all manufacturers of receiving sets approved by Popular Radio.



The 4D Inverse Duplex

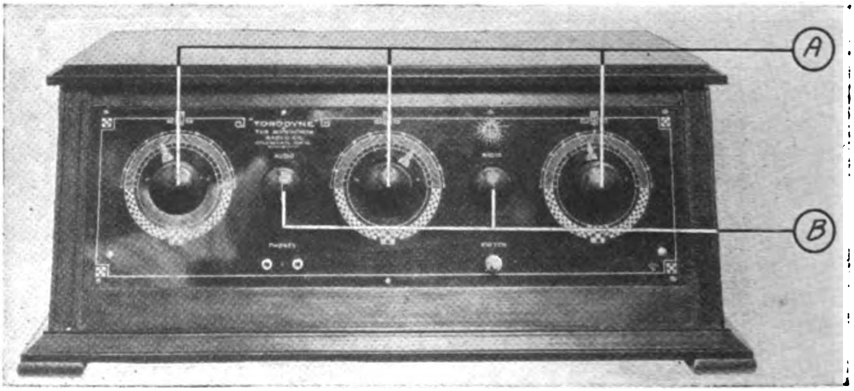
Manufacturer's Name; David Grimes, Inc.
Model Name; 4D Inverse Duplex
Number of Tubes; four
Type of Tuning; tuned-radio-frequency
Type of Detector; vacuum tube
Range on Phones; limit of atmospheric disturbance
Range on Loudspeaker; same
Cost Complete; **$160.00**
Antenna Recommended; 80 feet

Kind of Tubes for R. F.; UV-199 or C-299
Detector Tube; UV-199 or C-299
Audio Tubes; UV-199 or C-299
Type of "A" Battery; dry cells, 4½ volts
Type of "B" Battery; dry cells, 90 volts
Detector "B" Voltage; 22½ volts
Wavelength Range; 165 to 600 meters
Number of Tuning Controls; three
"A" Battery Current Used; ¼ ampere
"B" Battery Current Used; 5 milliamperes



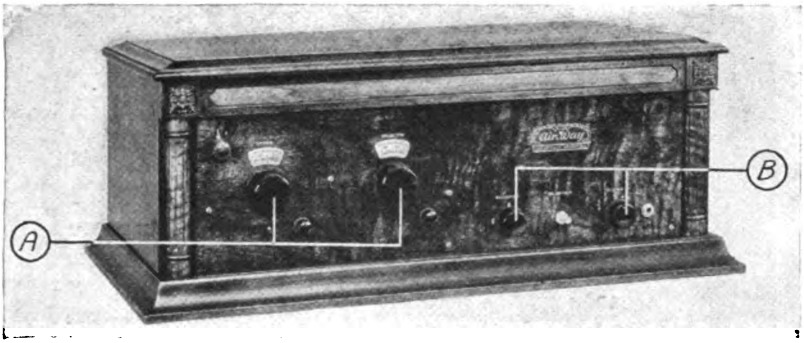
The Simplex SR-8

Manufacturer's Name; Simplex Radio Co.
Model; Type SR-8
Number of Tubes; five
Type of Tuning; tuned-radio-frequency
Type of Detector; vacuum tube
Range on Phones; coast to coast
Range on Loudspeaker; coast to coast
Cost; $65.00 without accessories
Antenna Recommended; 75 to 125 feet outdoor
Kind of Tubes for R. F.; UV-201-a or similar type
Detector Tube; UV-201-a or similar type
Audio Tubes; UV-201-a or similar type
Type of "A" Battery; storage, 6 volts
Type of "B" Battery; storage or dry cells, 90 volts
Detector "B" Voltage; 22 to 45 volts
Wavelength Range; 225 to 550 meters
Number of Tuning Controls; three
"A" Battery Current Used; 1.25 amperes
"B" Battery Current Used; 18 to 20 milliamperes



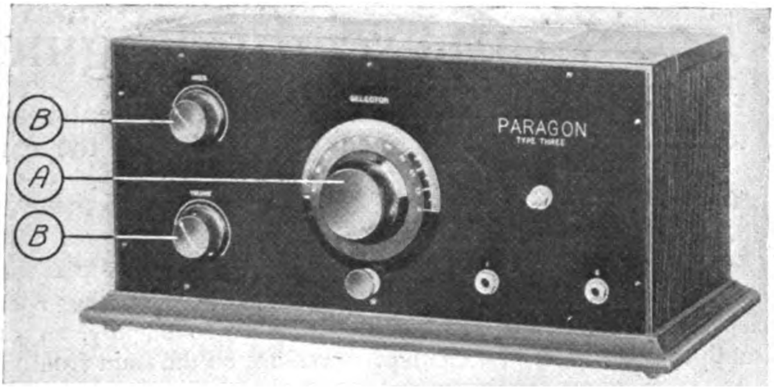
The Torodyne

Manufacturer's Name; Ainsworth Radio Co.
Model Name; Torodyne
Number of Tubes; five
Type of Tuning; tuned-radio-frequency
Type of Detector; vacuum tube
Range on Phones; (not stated)
Range on Loudspeaker; (not stated)
Cost; $100.00 without accessories
Antenna Recommended; outdoor
Kind of Tubes for R. F.; UV-201-a or C-301-a
Detector Tube; UV-201-a or C-301-a
Audio Tubes; UV-201-a or C-301-a
Type of "A" Battery; storage, 6 volts
Type of "B" Batteby; 90 volts
Detector "B" Voltage; 22½ volts
Wavelength Range; 220 to 550 meters
Number of Tuning Controls; three
"A" Battery Current Used; 1¼ amperes
"B" Battery Current Used; 15 to 30 milliamperes



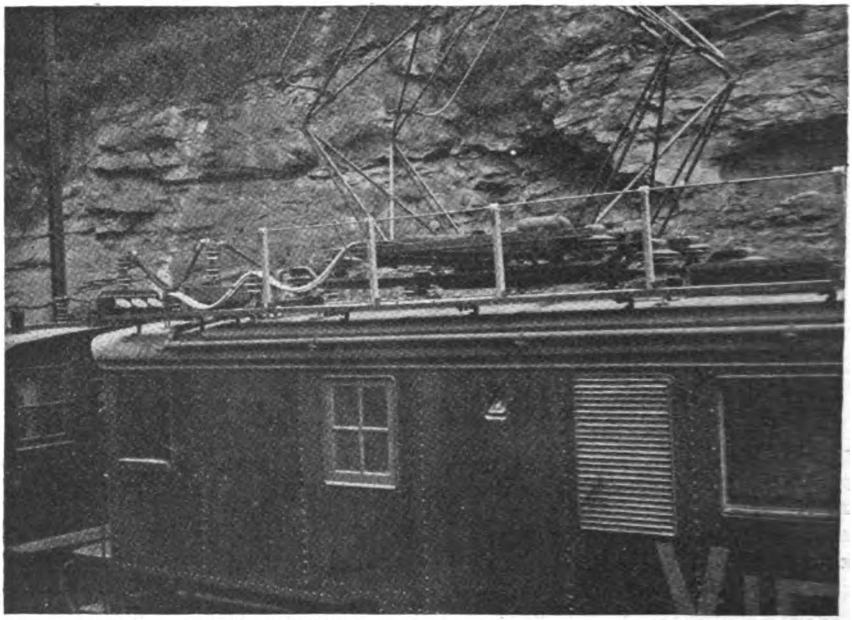
The Airway No. 61

Manufacturer's Name; Air Way Electrical Appliance Corp.
Model Number; No. 61
Number of Tubes; six
Type of Tuning; inductance
Type of Detector; vacuum tube
Range on Loudspeaker; 3,000 miles
Cost Complete; $98.50
Antenna Recommended; single wire, 75 to 100 feet
Kind of Tubes for R. F.; UV-201-a, C-301-a
Detector Tube; UV-201-a, C-301-a or soft detector
Audio Tubes; ¼ ampere
Type of "A" Battery; storage cell
Type of "B" Battery; any type
Detector "B" Voltage; 45 volts for 201-a tubes
Wavelength Range; 185 to 550 meters
Number of Tuning Controls; two
"A" Battery Current Used; 1½ amperes
"B" Battery Current Used; 17 milliamperes



The Paragon

Manufacturer's Name; Adams-Morgan Co., Inc.
Model; Type three
Number of Tubes; three
Type of Tuning; capacity
Type of Detector; vacuum tube
Range on Phones; (not stated)
Range on Loudspeaker; (not stated)
Cost; $48.50 (without accessories)
Antenna Recommended; 100 feet, single wire
Kind of Tubes for R. F.; standard makes
Detector Tube; standard makes
Audio Tubes; standard makes
Type of "A" Battery; standard makes
Type of "B" Battery; standard makes
Detector "B" Voltage; 20 to 45 volts
Wavelength Range; 200 to 580 meters
Number of Tuning Controls; one
"A" Battery Current Used; ¾ ampere
"B" Battery Current Used; 10 milliamperes



From a photograph made for POPULAR RADIO

THE ANTENNA ON THE ROOF OF THE MIDDLE CAB OF THE LOCOMOTIVE
It consists of a half-inch brass tubing, twenty-four feet long, supported by insulators mounted on upright posts. The antenna serves for transmission and reception alike.

A NOVEL AND PRACTICAL USE OF

Radio on Freight Engines

How radiotelegraph and telephone equipment makes team-work possible between locomotives at the front and rear of a mile-long train.

By AUSTIN C. LESCARBOURA

WERE it not for radiotelegraph and telephone equipment, it would not be practical to operate electric locomotives for hauling the mile-long coal trains up the steep mountain grades of West Virginia.

When steam locomotives are employed in the haulage of a long coal train, the practice is to place one Mallet compound steam locomotive at the head of the train and two at the rear for pushing. Thus the train is pulled and pushed at the same time, so that no undue strain is placed on the couplings of the train. When the train is about to start, the engineers of the two rear locomotives open their throttles, ever so slightly, so as to place a pressure on the train from the rear. This serves to take up some of the slack between cars. The front locomotive pushes back to take up the remaining slack, and then starts forward. Hence the front locomotive has the aid of the two rear locomotives, which have been pushing all the while and start moving the instant the front locomotive begins pulling. In this manner the motive power is synchronized. Signals for stopping, as well as starting, are given by means of steam whistle blasts, which carry over the mountains and valleys and numerous tunnels of this picturesque road.

When it came to operating the huge electric locomotives which replaced the steam giants, however, a serious problem arose in co-ordinating the tractive efforts of the units at the front and rear of the mile-long trains. First of all, the compressed-air whistles of electric locomotives do not carry as well as steam whistles. Secondly, it is poor practice and costly practice to apply forward pressure to the rear of the train before the train is ready to move. It cannot well be done with electricity; that feature, truth to tell, is one of the few advantages of steam.

The engineers who developed the electric locomotives hit upon the idea of short-wave radiotelegraph and telephone equipment in the cabs of the front and rear locomotives. And so well has the radio equipment functioned that the electric locomotives enjoy a marked superiority over the steam locomotives which they are replacing.

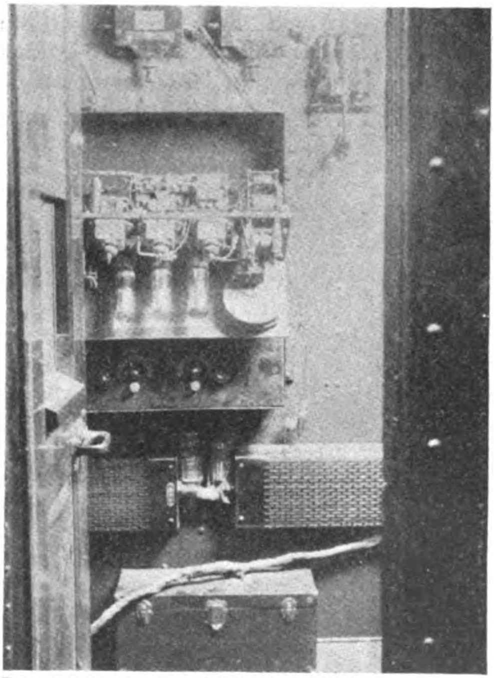
The radio equipment of the world's largest electric locomotives makes use of the guiding effect of the neighboring power lines, overhead trolley and the rails.

The transmitter and receiver are mounted in individual cabinets, placed one above the other, and mounted on the steel wall of the middle of the three sections comprising a complete electric locomotive. On the roof of the section that contains the radio equipment, along one side, is the antenna; it consists of a straight, twenty-four-foot length of one-half inch brass pipe, supported by porcelain insulators. The ground side is simply the frame of the locomotive.

The transmitter consists of a short-wave oscillator modulated by a 500-cycle tube oscillator. The circuit employed is a straight Hartley, with the antenna circuit coupled to the radio oscillator by means of a choke coil. There are two dials on the front panel of the transmitter, one controlling the antenna circuit and the other handling the oscillating circuit wavelength. The antenna circuit is brought into resonance with the oscillating circuit by obtaining the highest reading on the hot-wire meter. The transmitter operates over a wavelength of 110 to 140 meters, while its continuous-wave train is modulated at audio-frequencies ranging from 200 to 1,000 cycles, according to conditions.

The transmitter is rated as a 50-watt set. It employs three 50-watt tubes, one as the radio-frequency oscillator and two as modulators. Filament and plate currents are supplied by storage battery and a motor-generator set. The three transmitter tubes are arranged in series, so far as their filaments are concerned, in order to operate on the 32-volt storage battery of the locomotive which is employed for illumination purposes. The same 32-volt supply operates the motor-generator unit, which supplies the plate potential of 1,000 volts.

The receiving set, contained in a cabi-



From a photograph made for POPULAR RADIO

THE RADIO STATION IN THE CAB

The radio telephone and telegraph transmitter and receiver, with the cabinet of the former opened up and the working parts pulled out for inspection. The three 50-watt transmitting tubes are very much in evidence.

net directly below the transmitter, is of the three-tube, regenerative type. It makes use of three 201-a tubes, with two controls for tuning. The controls, when once set for the desired wavelength, are locked firmly in position. The same applies for the transmitter, since there is no object in constantly changing wavelengths. The receiving set has audio-frequency transformers tuned for a 500-cycle audio-frequency note, so as to produce the maximum signal strength on the normal 500-cycle modulation used in transmitting.

The control equipment is placed in the front locomotive cab, within ready reach and hearing of engineer and so-called fireman. This control equipment consists of a box which contains the ingenious switching and contact-making devices, with a pull cord and handle within reach of the locomotive crew, and a loudspeaker.

To use the radio equipment as a radio telegraph transmitter, the fireman or the engineer steps over to the control equipment and pulls the pull cord ever so slightly, which starts the motor-generator set, as well as lights the filaments of the transmitter tubes. Further pulling on the pull cord operates the modulator, which modulates the continuous-wave train and therefore sends a signal to the other electric locomotive. Ordinarily, the radiotelegraph is used for simple signals rather than for intricate telegraph signalling. Obviously, just so long as the electric locomotive is in operation, the tubes of the receiving set are turned on, ready for signals at any time.

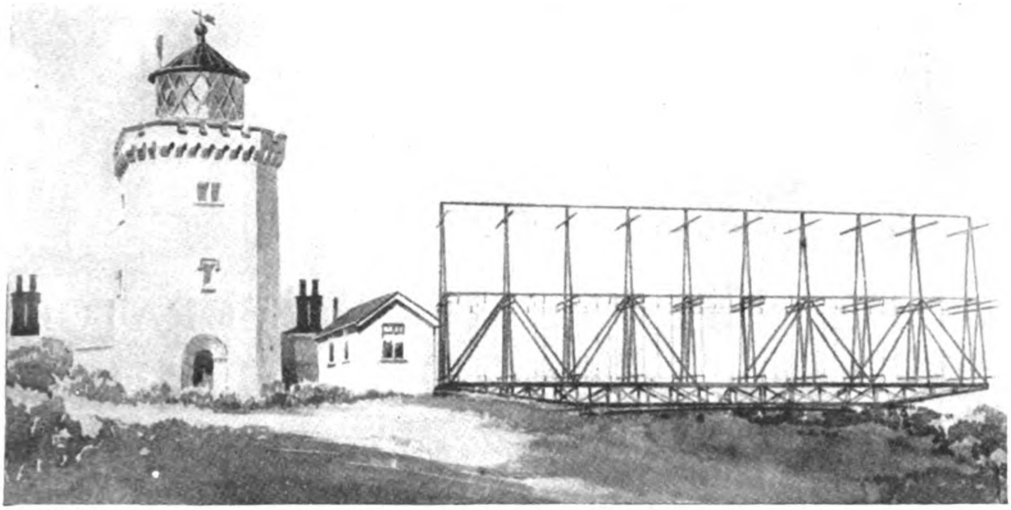
When it comes to radiotelephoning, it is necessary for the member of the locomotive crew to go to the transmitter set, which is provided with a microphone on the front panel. Also, a pair of earphones is plugged into the receiving set. A flip of a switch connects the radiotelephone arrangement, ready for talking.

The radio equipment on the world's largest electric locomotives is a forerunner of a new day in railroad operation, when the train crews may keep in constant touch with other locomotives and with the train dispatchers.

Kadel & Herbert

HOW TO DISTINGUISH POSITIVE FROM NEGATIVE WIRES

Dissolve some common table salt in a glass of water, and dip in the ends of the battery wires. Tiny bubbles will form about the negative tip.



Kadel & Herbert

THE ANTENNA OF THE RADIO LIGHTHOUSE AT DOVER, ENGLAND

The old tower and revolving light can be seen together with the new beam aerial, which is of the grid type. The energy radiated to any one spot is between thirty and forty times as much as can be obtained from a simple broadcasting antenna, using the same energy in the transmitter.

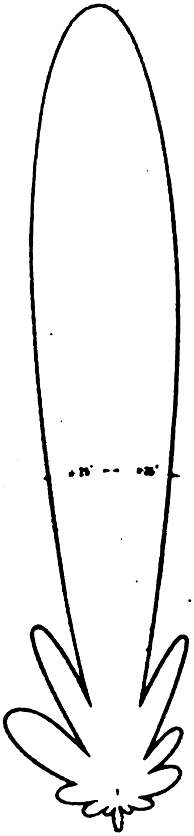
A Radio Transmitter That Pierces Fog and Storm

TO guide ships safely through the dense fogs that settle down on the English Channel and that make useless the ordinary type of lighthouse, a radio lighthouse that uses an application of the beam radio principle has been installed at South Foreland.

A six-meter transmitter is used with an antenna so designed that practically all of the energy is radiated in a beam fifteen to twenty degrees wide. This antenna is slowly revolved and a different Morse letter is sent out for each point of the compass.

On board the ship the navigator may hear as many as five letters. He chooses the loudest letter as giving the direction of the ship from the lighthouse: a chart gives the direction corresponding to the letter received. By taking various letters as the ship moves on, each giving him his new position in regard to the transmitter, he may calculate the correct course for the ship to follow.

The receiving apparatus is so inexpensive and easy to operate that it is within reach of even the smallest boats. And in addition the Morse letters are sent out at a speed of only ten words a minute, so that only an elementary knowledge of the code is necessary to understand them.



The radiation curve; note how the beam narrows and becomes sharply directional.

IN THE EXPERIMENTER'S LABORATORY

CONDUCTED BY LAURENCE M. COCKADAY

A Vacuum Tube as a Voltmeter

LIST OF PARTS:

VT—Federal vacuum tube socket and UV-201-a or C-301-a tube;
R1—Amperite filament resistance No. 1A, with mounting;
R2—Amsco potentiometer, 400 ohms;
MA—Hoyt milliammeter, range 0 to 15 milliamperes;
Baseboard, 7 inches by 9 inches; 11 Eby binding posts; 6 brass angles; 2 composition strips, 1 inch by 7 inches, and 1 inch by 5 inches respectively; bus wire; solder; etc.

THE peculiar characteristics of a vacuum tube make it adaptable to many more uses than is generally realized. One of the important ones is its use as a voltmeter for measuring all ordinary voltages, either direct or alternating current, from a fraction of one volt up to several hundred volts.

Thus with an inexpensive voltmeter, preferably one with a double range of say 0 to 10 and 0 to 100, it is possible, by the use of a vacuum tube, connected as shown here, to use this meter for measuring voltages far above the range of the meter. Not only this, but alternating-current voltages may be measured even though the voltmeter available is a direct-current meter.

The circuit described here also has other uses. For instance, it enables the experimenter to determine the characteristic curves of his vacuum tubes and it serves as a reliable tube tester. Still further uses will suggest themselves to the experimenter after he has the circuit in operation a short time and becomes familiar with its operation.

The action of the tube as a voltmeter is based on what is known as the "mu" of the vacuum tube. Any voltage properly connected in the grid circuit of the tube will prevent a much higher voltage in the plate circuit from being effective. If the tube used is a UV-201-a, with standard characteristics, a plate voltage of over 80 will be required to cause a current flow in the plate circuit, if the grid voltages (negative) are as much as 10 volts. The "mu" of the UV-201-a tube is 8, therefore the plate voltage must be more than eight times the grid voltage if there is to be any plate current flow.

Hence it is evident that we may measure an unknown voltage in the plate circuit if we have means available for measuring the grid voltage and for knowing when the plate current is O. For instance, if the battery "B" in Figure 1 is of unknown voltage we can alter the voltage of battery "C" in the grid circuit until there is zero current flow in the plate circuit. At this point the two circuits are said to be balanced and their voltage ratio is equal to "mu" of the tube, which is approximately 8, in the case of a UV-201-a tube. Therefore, the unknown plate voltage is figured by multiplying the grid voltage by the "mu" of the tube, 8.

This is the theory of the measurements. However, in actual practice conditions are slightly different. It is impracticable to obtain an accurate zero plate-current reading, to determine when the voltages of the two circuits balance each other out. Moreover, "mu" varies with different tubes, even of the same type, and it also varies with changes in filament temperature. It is therefore necessary to first of all calculate the "mu" of the tube to be used; to use some definite unit of current in the plate circuit, rather than zero; and to keep the filament voltage constant.

The method used is to set up the circuit with a known plate voltage and a known grid voltage, which are always left in the circuit. The plate voltage may be 90, for instance, and the grid voltage 3. If a milliammeter is connected in the plate circuit it will indicate a plate-current flow under these conditions of approximately 4 milliamperes. We care nothing about the exact amount of current flow, however, so it is not necessary to have an accurate reading milliammeter; in fact, a cheap voltmeter such as may be purchased for a few dollars will serve the purpose if connected in place of the meter MA in Figure 1. This latter will, of course, not give readings in milliamperes, but if the point on the dial to which the hand goes with the above voltages in the circuit is noted, that will be all that is necessary.

Assuming that the circuit is connected up as shown in Figure 1 and the voltages mentioned above are connected into the circuit at "B" and "C," we are ready to start measurements. The first step is to measure the "mu" of the tube used. For this purpose a known voltage, X1, is connected in series with the voltage already connected in the plate circuit. This will cause the needle of the meter, MA, to go up the scale.

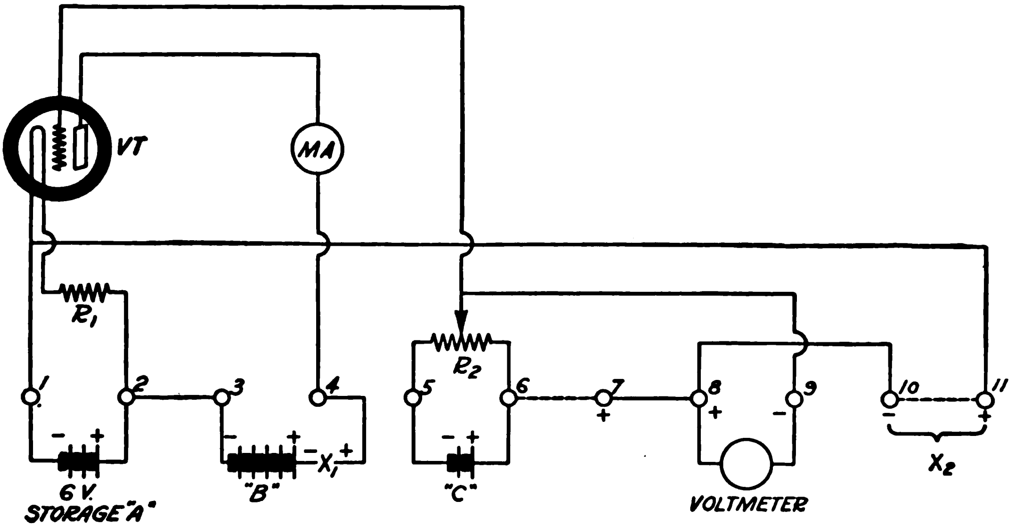
Now adjust the potentiometer until the indicator of the meter, MA, comes down again to the original setting. If adjustment of the potentiometer will not bring this about, take off connector between terminals 6 and 7 and connect additional voltage to these two terminals, negative side to No. 6 and positive to No. 7. Again readjust the potentiometer. When the MA needle finally comes to rest at the same point as when only 90 volts were used at "B" and 3 volts at "C," the exact voltage at "C" and "B" are read with a regular voltmeter. These voltages will include not only the original 90 volts at "B" and 3 volts at "C," but also the voltages that were added to both.

Next, subtract the original voltage of 90 from the new reading at "B" and the original grid voltage of 3 from the new reading at "C." This will give the voltage that was added. Say the added voltage at "B" is 45, and an added voltage at "C" of 5.25 was needed to balance out this added plate voltage, it is evident that 45 divided by 5.25 will give the "mu" of the tube which in this case would be 8.57.

Having found "mu," suppose we want to measure an unknown direct-current voltage. We simply connect it in series with the 90-volt battery at "B." Next we add more battery at "C" until the plate current reading is at the same setting as in the two previous measurements. With the voltmeter we measure the new voltage of "C" and subtract the original voltage of 3. Let us assume the difference is 10 volts. We have just found that for every 8.57 volts added at "B" it is necessary to balance with 1 volt at "C" (that is what "mu" really means), therefore, if 10 volts were added to "C" to balance the voltage added at "B," the latter must have been 85.7 volts.

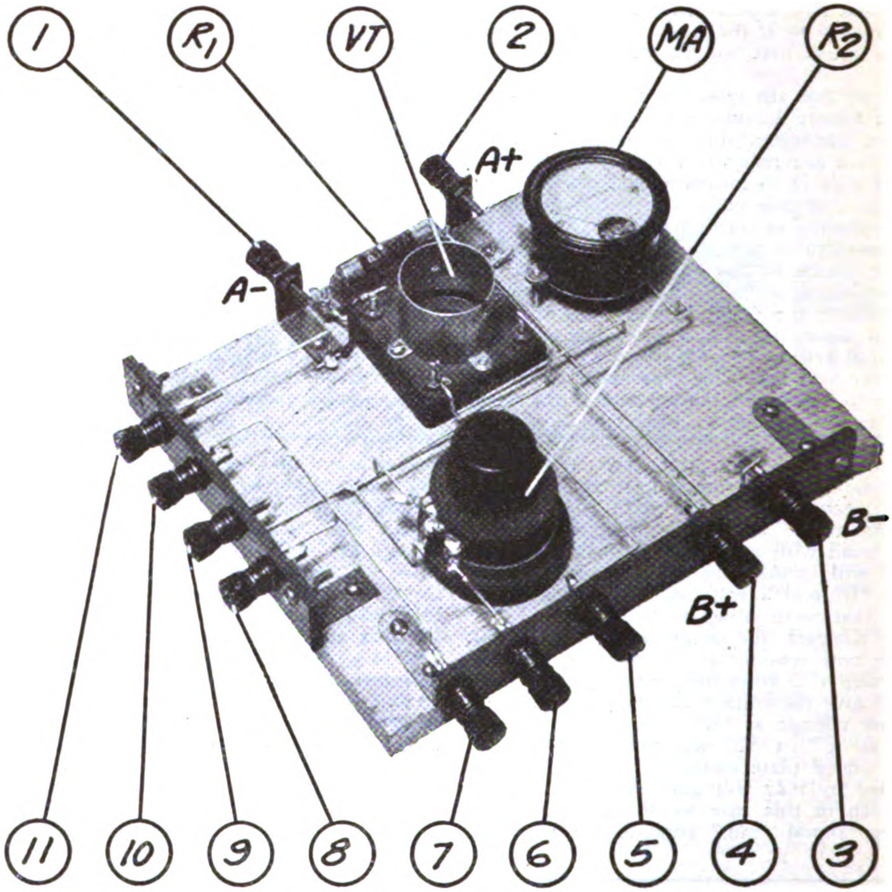
If this method is carefully used the accuracy of the vacuum tube voltmeter is greater than the average voltmeter used in radio work. Measurements taken in the laboratory proved the equipment shown in Figure 2 to be accurate within one-half of one percent up to several hundred volts. Where the voltage to be measured is low it may be placed in the grid circuit, and balanced out by adding voltage in the plate circuit. The unknown voltage added in the grid circuit will then be the added plate voltage divided by "mu."

Or, to measure small unknown voltages, up to 10, the substitution method may be used in the grid circuit. The circuit is set up with say 10 volts at "C" and perhaps 135 volts at "B." The MA reading is then noted. Next the small unknown voltage is connected across terminals 10 and 11 and the voltage at "C" is reduced by adjustment of the potentiometer until the same MA reading as before is obtained, leaving the voltage at "B" the same throughout. The difference in the readings of the voltmeter across "C" before and after the unknown voltage was added at "C1" will be the unknown voltage.



THE WIRING DIAGRAM OF THE VACUUM TUBE VOLTMETER

Figure 1: *It will be noted that terminals 6 and 7, also terminals 10 and 11, are shown short circuited. In certain measurements it is necessary to connect additional voltage in the grid circuit, and it is for this purpose that these terminals are used. Their use is explained in the text.*



THE VOLTMETER READY FOR USE

FIGURE 2: *All terminals are clearly marked. The designating symbols are the same as those used in the text, and in Figure 1.*

This method of measuring low voltages is only practical in the case of alternating current, of course, as low direct current voltages can be read directly on the regular voltmeter.

Direct-current voltmeters will not measure alternating-current voltages but with the systems described here the peak voltage of any alternating current may be measured accurately in exactly the same way as the direct-current voltages were measured, making use only of a direct current voltmeter and a direct current milliammeter (or another voltmeter as explained above), in addition to the vacuum tube circuit shown in Figure 1.

This system has advantages that even alternating-current meters do not have. For instance, measurements of alternating current of any frequency may be accurately measured. Moreover, this vacuum-tube voltmeter has almost infinite resistance and can therefore be shunted across any circuit without having any effect on the functioning of that circuit, therefore the readings show true voltage. In the case of the ordinary voltmeter if the resistance across the voltage terminals is higher than that of the meter the constants will change when the meter is connected and the voltage reading will vary greatly from the actual voltage of the circuit.

In using this voltmeter arrangement the following suggestions will be helpful.

Be sure that the "A" battery voltage is constant. In the hook-up shown an "amperite" fixed filament resistance is used to maintain constant voltage across the filament. However, when the "A" battery is nearly discharged the filament voltage will drop below this constant point, or when the battery is freshly charged the voltage will be higher for a short time. It is therefore advisable to measure the "mu" of the tube before starting a series of readings with this device. Or if an accurate low-voltage voltmeter is available, measure the voltage across the filament occasionally to make sure it does not vary.

In making measurements of unknown voltages in the plate circuit, short circuit terminals 10 and 11 with a piece of bus wire, and if the unknown voltage is less than 45, terminals 6 and 7 may also be short circuited. In all cases the voltage across the potentiometer (terminals 5 and 6) should be 6. If it is higher than this the drain on this portion of the battery, through the potentiometer winding, will be unnecessarily high. This permits a voltage regulation from zero to 6 volts simply by varying the potentiometer knob. If higher than 6 volts is needed in the grid circuit to balance the plate voltage, it is added across terminals 6 and 7. There is no drain on the portion of the battery thus connected. If preferred, where voltages over 10 are to be used in the grid circuit, terminal 6 may be left unconnected, in which case the potentiometer serves as a variable series resistance (rheostat) with only a slight current drain on the battery, connected across terminals 5 and 7.

The same tube should always be used in the meter because of the difference in "mu" in different tubes of the same type.

When making measurements, leave the voltmeter connected to terminals 8 and 9, because if the two circuits are first balanced and then 10 and 11, it will be found that the circuits are no longer balanced. The best plan is to leave the voltmeter in the grid circuit until the circuits are balanced, then note the voltmeter reading. After this the meter may be removed and connected across the plate battery (if the same voltmeter is to be used for measuring the plate voltage) as when measuring "mu" of the tube for instance. A separate meter is necessary for use in measuring the plate current. This may be either a milliammeter or another voltmeter. It is understood, of course, that to measure the voltage of a circuit the voltmeter is connected in parallel with the circuit. To measure current the meter is connected in series with the circuit.

The batteries used with the vacuum-tube voltmeter may be the regular type of "B" batteries for the plate circuit. For the grid circuit the usual type of "C" batteries may be used, or a "B" battery if this is more convenient. The "C" batteries are tapped every 1½ and 3-volts, however, and thus provide more gradual voltage changes than the "B" type of battery.

—S. Gordon Taylor

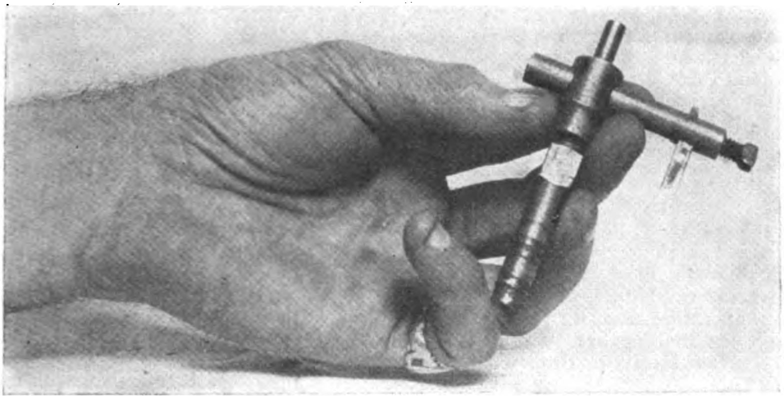
How to Drill Large Holes in Panels

The reduction in the price of panel-mounting meters by the various manufacturers, together with the introduction of the two-inch size, has made the meter more popular than ever with the home constructor.

Certain difficulties, however, present themselves in mounting on the panel. Perhaps that of drilling the large holes in the panel for the flush mounting type gives the greatest amount of trouble.

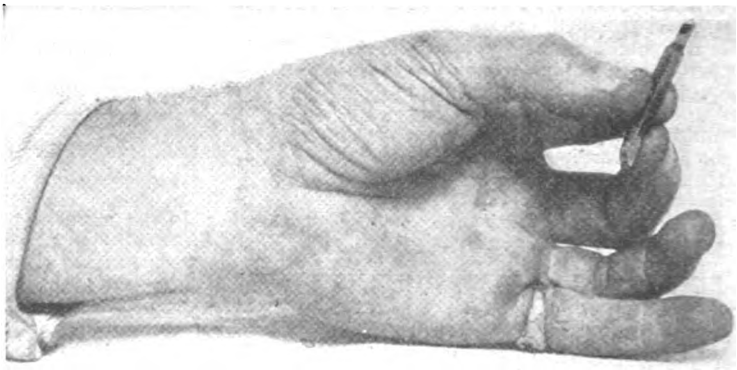
There are several fly cutters on the market, but not all of them are adaptable to this class of work, due to the fact that in some of them the steel cutting tool is not held rigid enough to cut properly. Extreme rigidity throughout is necessary in this tool. Figure 3 gives a good conception of a tool of this type; note its sturdiness of construction and simplicity. Observe in Figure 4 the shape of the cutter. If a fly cutter of this type is used, drilling takes but a few minutes. It is best to place a piece of cardboard, slightly larger than the panel, on the bench or table, to avoid scratching the face of the panel. The center hole for your meters should then be punch-marked and a hole drilled corresponding in size to the size of the centering guide of the fly cutter. (Some fly cutters are equipped with a drill instead of a centering guide, but the experience of the writer has been that this type has lacked the necessary rigidity.)

Now adjust the fly cutter for the proper diameter, and prove this by trying it out on a piece of wood to assure yourself that the finished hole will be the proper diameter for the meter. This proving method is important in



THE TOOL USED FOR BORING LARGE HOLES

Figure 3: *In mounting voltmeters or milliammeters on a panel the large hole necessary can easily be drilled if a cutter of the type shown is used.*



THE SHAPE FOR THE CUTTING EDGE

FIGURE 4: *This should be ground down to a sharp triangle for best results in making a clean, round hole in the panel.*

view of the fact that if a mistake is made in the diameter it will entail considerable labor to rectify it. Drilling may now be started.

Be careful to hold the brace in which the fly cutter has been tightened in an upright position as is possible so as to cut evenly. Proceed to cut a little over half way through panel, when the brace should be removed, the panel turned over and drilling resumed. The steel cutter will probably drop through the remaining uncut bakelite at the point that is thinnest. Make sure that your panel is resting on a flat surface and with a sharp blow from a hammer the "cutting" may now be broken loose.

A narrow fin may now be removed from the cut edge by means of a bastard file and the meter slipped into position for spotting the holes for the screws that go through the rim of the meter. These are usually three in number. These holes may be readily marked by holding the meter in proper position and marking the panel with a scratch point. Remove meter and drill the panel at the three marked places with a No. 31 drill, then tap with a 6-32 tap. Nickel round-head 6-32 screws may be used or brass round-head, which may be blacked afterward with a suitable enamel or paint scantily applied with a small brush.

Some manufacturers have devised a meter which does not necessitate the drilling of these three holes, and the meter is held to the panel from the rear by means of two jam screws. This facilitates quick mounting.

—ROBERT W. TAIT

A Shunt Plate Feed for Loudspeakers

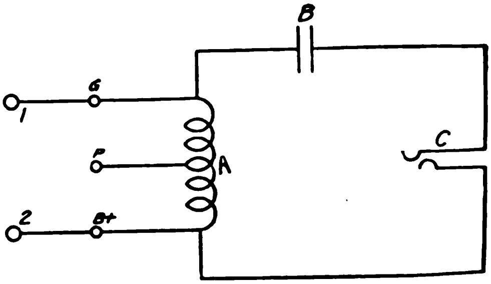


FIGURE 5: *This is the electrical circuit diagram for the choke, the condenser and the jack.*

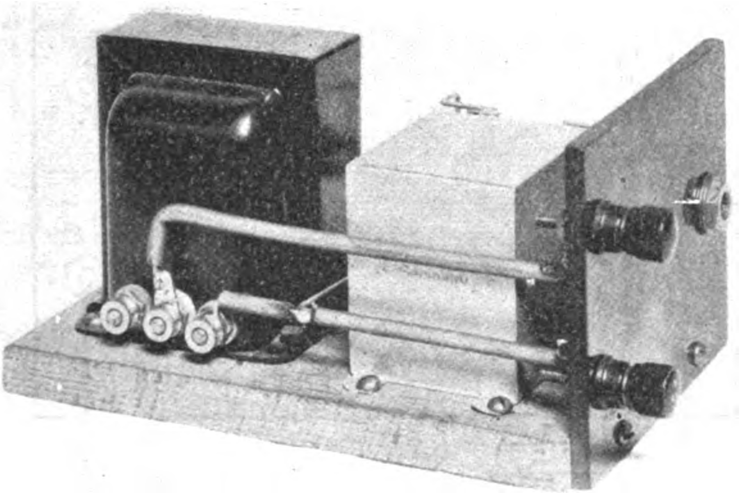
MANY loudspeakers that use the ordinary telephone type of diaphragm and electromagnet contain an adjustment for varying the distance between the diaphragm and the magnet poles so that volume can be controlled. This is because the direct current that flows through the magnet coils in this type of unit produces a stress in the diaphragm that either attracts or repels the diaphragm in accordance with the polarity with which the loudspeaker is attached.

For this reason, some loudspeakers also require that the connections be made in a certain direction so that the diaphragm will be permanently attracted toward the magnet when the tubes are in operation and the plate current flows through the loudspeaker. This gives the diaphragm a certain inertia or drag which produces some distortion.

In the case of the type of loudspeaker in which the diaphragm is under no magnetic stress such as when a balanced armature is used, the moving coils are usually of fairly low impedance, and this places a considerable load on the output of the tube with which they are connected in series.

A simple small unit that will improve considerably the operation of most loudspeakers is explained and information regarding construction given in this article.

In referring to Figure 1, the reader will notice that the unit consists of a high impedance

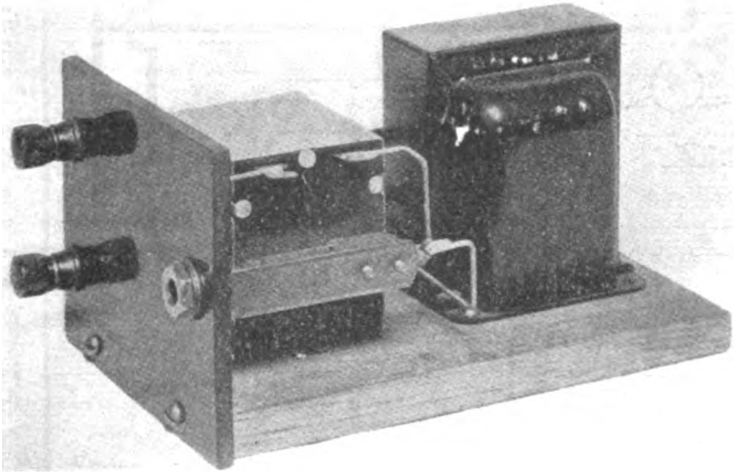


VIEW OF THE UNIT FROM THE LEFT

FIGURE 6: *This picture shows how the Thordarson autoformer is mounted on the wooden baseboard and wired to the two binding posts. Notice that the top binding post is connected to the middle terminal of the autoformer. This connection may be tried either here or on the left end terminal which in some cases gives a little better result.*

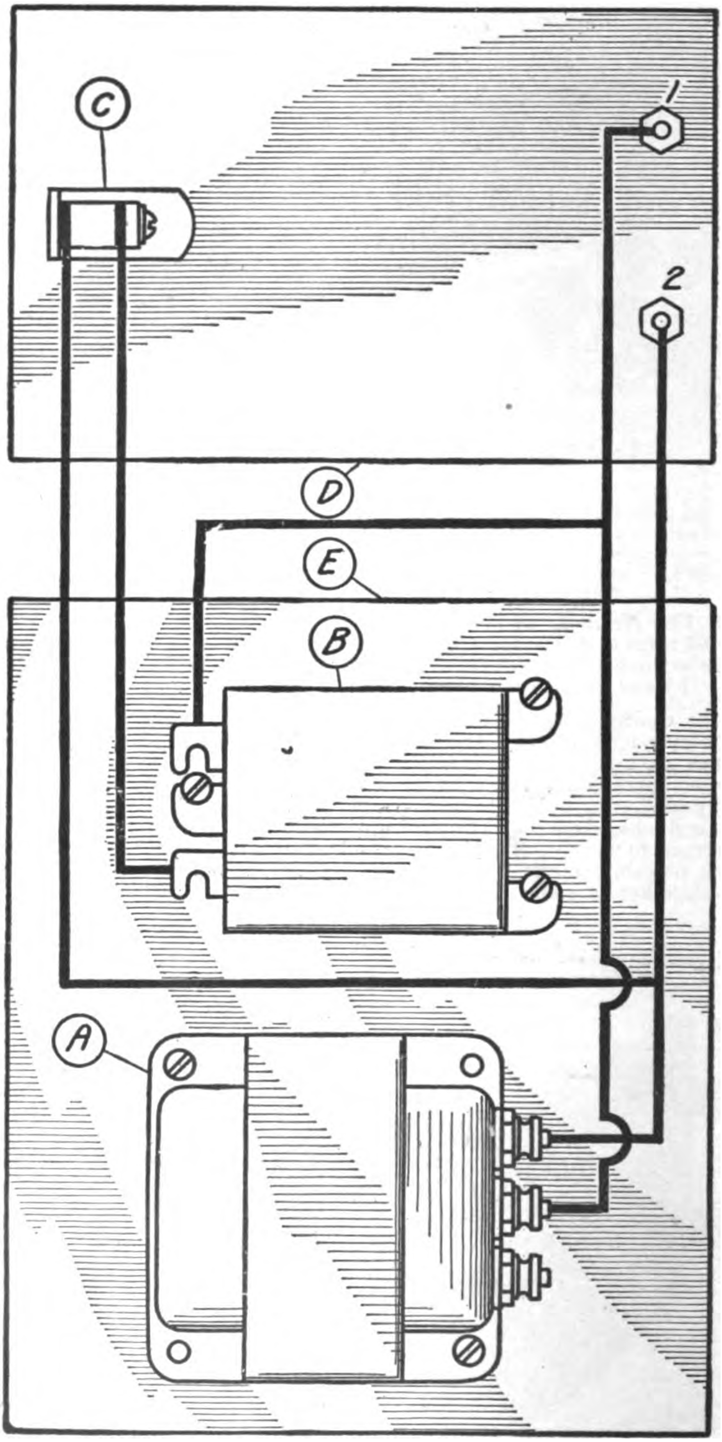
coil which may be connected across the plate and "B" battery output terminals of a receiver. Shunted across this are a large fixed condenser and a jack for accommodating the plug attached to a loudspeaker.

The impedance coil which is designated in the diagram as A serves to furnish the plate of the tube with the necessary direct-current potential. The loudspeaker is connected in circuit, however, through the fixed condenser B, which is in series with the loudspeaker by means of the jack C. This allows the alternating current output from the receiver to flow from the plate of the tube through condenser B and the loudspeaker and jack to the filament circuit through the "B" battery, but at the same time it prevents any direct current from flowing through the loudspeaker itself.



VIEW OF THE UNIT FROM THE RIGHT END

FIGURE 7: *This illustration shows how the Tobe 4 microfarad condenser is mounted and connected to the jack. This small unit is easy to make and simple to wire up.*



THE PICTURE WIRING DIAGRAM FOR WIRING UP

FIGURE 8: *This drawing gives the exact connections for the parts that go into the shunt feed unit. The wiring is shown in a heavy black line.*

This simple little unit will help the experimenter in obtaining better quality of reproduction from almost any loudspeaker now on the market and will in some cases also *increase the volume* to a considerable extent.

In making up a unit of this type, it will be necessary to obtain a small bakelite panel 3½ by 4 inches in size and a small block of wood to be used as a base 4 by 6 inches by ½ inch. These should be fastened together at right angles by means of two screws as shown in the two accompanying photographs.

Then mount on the baseboard a Thordarson Autoformer A and a Tobe fixed condenser B of 4 mfd. Then mount on the panel the two Eby binding posts and the Pacent single-circuit jack C as shown and wire up as indicated in the picture wiring diagram which is given in Figure 2.

The two binding posts of the unit then should be connected to a plug which is inserted in the jack of the set which has at previous times been used for general loudspeaker operation. The loudspeaker plug should then be inserted in the jack C and the unit is ready for operation.

There will now be no direct current flowing through your loudspeaker but only the alternating current of the plate circuit in your last tube will have passed through the loudspeaker coil windings.

As stated before, this unit will improve reception on almost any type of loudspeaker, it will increase the life of some loudspeakers and it will prove to be interesting and helpful to any experimenter who is looking for the utmost in quality of reproduction.

—LAURENCE M. COCKADAY

The Relative Merit of Some Types of Inductance

THE average radio experimenter is deeply interested in the subject of losses in radio apparatus; and as the greatest variation in loss is present in coils, here are some comparative data on the subject.

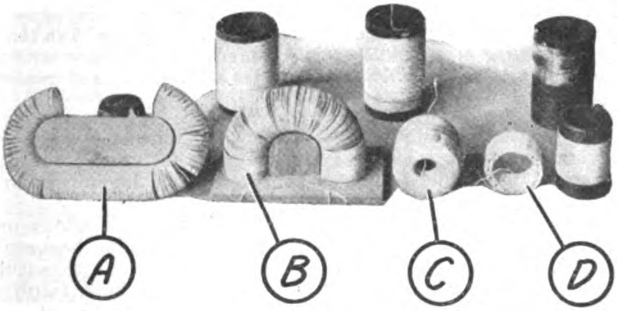
The difference in resistance at broadcast frequencies between the poorest variable condenser and the best obtainable is perhaps only one or two ohms, while coils of equal inductance may vary as widely as thirty ohms or more. It is obvious, therefore, that the coil is by far the more important of the two.

Mr. W. W. Harper has proposed a method of expressing the relative merit of coils as follows: The resistance is measured (at enough points to insure accuracy) over the wavelength band in which the coil is to be used (say from 200 to 550 meters). The pure inductance of the coil is also determined. The pure inductance is then divided by the *average* resistance of the coil over the entire wavelength range. [This average resistance is obtained either by taking the single integral of the function—providing the equation for the curve has been obtained—existing between wavelength or frequency and resistance; or by the use of a planimeter; or by any other method used in finding the average height of a curve above its X axis.] The result is in terms of microhenries per ohm. Thus if we have two coils each of 500 mh. inductance and if the average resistance of one is 10 ohms and of the other 15 ohms, their figures of merit are respectively 50 mh/ohm and 33.3 mh/ohm.

In the present discussion, however, it was thought best to show $\frac{L}{R}$ (inductance divided by resistance) for each of the wavelengths at which measurements were made. These results have been plotted as curves in Figure 1.

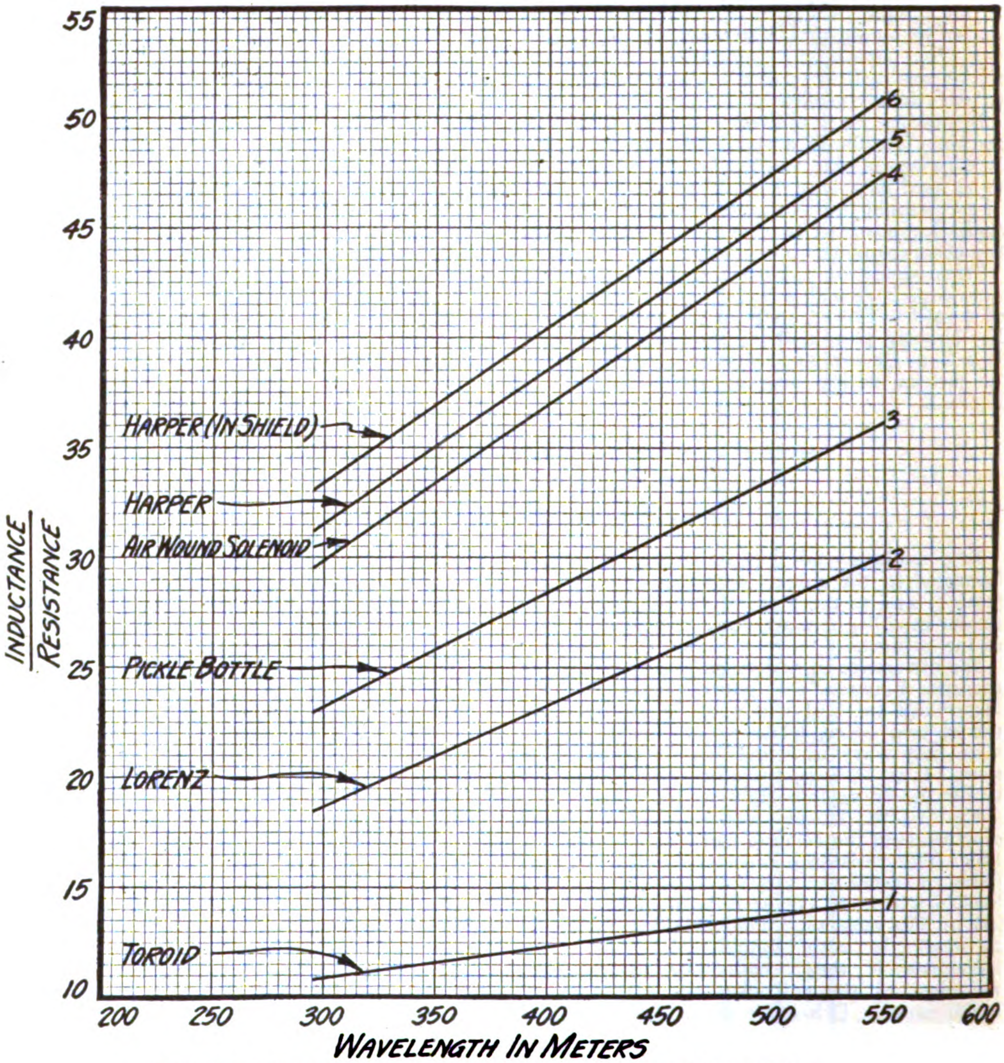
It will be noticed that these curves go only as low as 300 meters. This was the lowest wavelength to which the condenser used would tune the largest coil. In actual practice the resistance below 300 meters is not very serious because tuning is usually sharpened by the regeneration ordinarily present. Therefore, it was thought that stopping at 300 meters was not a serious omission.

The present trend seems to be toward coils that have confined fields, and in considering the



SOME OF THE COILS THAT WERE TESTED

FIGURE 9: *The inductances that were used in finding the relative merit of different kinds of coils at various frequencies. The results that were determined indicate that the solenoid type of coil still remains the best of any of the coil shapes that have been brought out. The coils A, B, C and D are those which the author refers to specifically in the text.*



THE RELATIVE MERITS OF VARIOUS TYPES OF COILS

FIGURE 10: *This series of curves shows the values of inductance divided by resistance for six different types of winding. Notice that the three upper curves which in this case happen to be practically straightline have a much greater inductance-resistance ratio than the other types of winding. These three curves are for solenoid types of winding.*

curves this should, of course, be taken into account. The problem of preventing interaction between coils has several apparent solutions: First, we may turn them at the angle of least coupling; second, we may confine the magnetic field by shaping the coil in the form of a torus or through some other scheme of winding; third; we may use a coil having only a semi-confined magnetic field and shield against the unconfined portion of the field; and fourth, we may obtain field confinement through shielding alone. In investigating this problem, all of these methods were tried.

The first method has the disadvantage that the angle is rather critical and varies with coil shape. (It also varies slightly with frequency.) Scheme two solves the problem of magnetic interaction but it gives an extremely poor coil from the standpoint of selectivity and losses.

Note that both methods one and two allow electrostatic coupling between coils.

Method three is successful in that a fairly good coil can be built (with no coupling either magnetic or static) as the coil is almost unaffected by the presence of the shield.

Solution four gives by far the best results in that it is possible to completely shield a coil and still maintain its electrical properties practically as good as those obtainable from the same coil in free space, as its constants are altered in about the same proportion.

There are two classes of shielding materials available: Magnetic substances function chiefly by deflecting the magnetic flux from its normal path to a path of lower magnetic reluctance, thus confining it to the space within the shield; non-magnetic materials prevent field escape by setting up a secondary field which is 180 degrees out of phase with the main field striking the shield, and practically equal to it. This presupposes the setting up of eddy currents within the shielding material. The effect upon the enclosed coil is similar to taking turns off it: i.e., both the inductance and resistance are decreased. Of the available classes of materials for shielding, certain non-magnetic substances are therefore best in that they produce the lesser losses.

A few of the coils having semi-confined fields are shown in the illustration, Figure 9. Coil A is an oval shaped coil similar in some respects to the torus but having superior electrical characteristics. The ideas involved in this coil are: First, to have a fairly long straight section (solenoid) so as to obtain efficient operation as a radio-frequency transformer; second, to have the two opposite ends (whose instantaneous magnetic polarity is opposite) pointing directly at each other so as to obtain fairly close field confinement; and third, to have the two opposite ends (whose instantaneous electrical polarity is opposite and greatest in magnitude of any two points on the coil) widely separated, so as to reduce distributed capacity.

Coil B is a semi-torus, or horseshoe-shaped coil which is inferior to coil A, both as to radio-frequency resistance and action as a transformer. It might be well to mention here that, from the standpoint of energy transfer between two windings, the torus is much inferior to a plain solenoid. That is, the voltage step up between primary and secondary falls off much more rapidly as the wavelength is increased, than is the case with solenoids. This action is the reverse of what we require because at higher wavelengths the tendency toward feed-back is reduced and, as a result, a set built with coils having such a drooping characteristic will give widely varying results over the tuning range. See Table 1.

Table 1

Voltage Amplification with 201-A Tube

WAVE-LENGTH	SO-CALLED LOW-LOSS TORUS	STANDARD NEUTROFORMER
250	8.6	10.0
500	4.5	9.6

The impression seems to exist also (or, at least, we are led to believe that it exists) that there is nothing, after all, to this matter of feed-back through grid-to-plate capacity. Another curious belief is that, while it is desirable to prevent magnetic feed-back through the use of coils with confined fields, for some carefully-passed-over reason, it is undesirable or unnecessary to prevent this same feed-back through tube elements by oscillation-preventing devices. As an example of what is meant, much of the literature now appearing on toroidal coils stresses the desirability of eliminating inter-stage magnetic coupling and at the same time makes the rather inconsistent statement that anti-regenerative devices are successful only in so far as they cause a sacrifice in efficiency. A third superstition is that the use of anti-regenerative control causes poor quality. Only a little superficial thought is necessary to show the fallacy of these three ideas.

Coil C is of unusual shape in that, instead of having its opposite ends turned toward each other externally as in A, they are tucked inside the main coil. Coil D is a Lorenz type winding whose characteristics are given by curve "2" in Figure 1. The other coils in the illustration are solenoids of different designs. Several other types of coils were investigated but are not considered worth discussing.

As to shielding, this has heretofore been accompanied by losses too great to be tolerated. The solution was, to the best of the writer's knowledge, first successfully accomplished by Harper in the design of his "Metalloid" coil. Magnetic substances were found too sluggish in the accommodation of their molecular arrangement to magneto-motive forces at radio frequencies. Harper's coil involves the correct co-ordination of coil size and shape with shield spacing and material. This type of coil, modified to suit the circuit conditions, is being used in the Penetrola and Isofarad receivers.

Incidentally, coil pick-up is not a serious factor in selectivity. In fact, the amount of energy picked up in a 3-inch coil is negligible compared to that collected by the average antenna.

In Figure 10, curve 1 is for a so-called low-loss torus coil; 2 is for the Lorenz winding shown in the illustration; 3 gives the characteristics of a self-supporting solenoid of octagonal cross section; 4 is for a 3-inch solenoid of No. 22 DCC wire wound on a skeleton frame; 5 is for a coil designed on the principles determined by Harper (its bulk, for the same inductance is less than half that of coil 4); and 6 is for the same coil (5) shielded.

In conclusion: first, magnetic field confinement is not sufficient to prevent coupling between stages in a radio-frequency amplifier (even neglecting grid-to-plate capacity); second, magnetic field confinement does not prevent signal pick-up within the set; third, from the standpoint of selectivity, the best torus coil is by far the poorest coil investigated; fourth, torus coils are inefficient as radio-frequency interstage coupling transformers; fifth, it is possible to completely shield a coil and obtain at least as good electrical qualities as are present in the best types of coils in free space; and lastly, interstage coupling transformers whose losses are low and whose voltage step-up is at all near the maximum obtainable value cannot be used without some means for preventing self-oscillation. Therefore some losses are necessary in coils used in circuits employing no anti-regenerative device.

—Byron B. Minnium

WHAT READERS ASK

CONDUCTED BY HUGH S. KNOWLES

IN justice to our regular subscribers a nominal fee of fifty cents per question is charged to non-subscribers to cover the cost of this service, and this sum must be inclosed with the letter of inquiry. Subscribers' inquiries should be limited to one question or one subject.

Automatic Voltage Control on a Resistance-coupled Amplifier

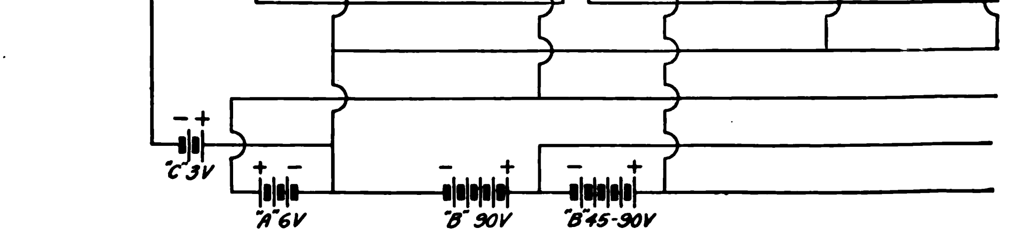
QUESTION: I have a single tube receiver which gives me very good headphone operation on even distant stations. I bought it with the intention of adding more tubes, to secure loudspeaker operation, at a later date. A friend of mine has an amplifier which he built according to the instructions you gave in the "Simple How-to-Build" article No. 7 which appeared in the March, 1925, issue of POPULAR RADIO. It gives excellent volume and quality when used with my receiver, but I would like to build one using filament control jacks so the unused tubes will be automatically turned off. If possible I would like to further simplify its control by using some sort of automatic filament control.

WILLIAM HULL

ANSWER: In Figure 1 you will find a diagram of the type of amplifier you want to use. It uses a stage of transformer and two stages of resistance-coupled amplification. The jacks control the number of stages of amplification used, turn off the unused filaments and connect the 90-volts "B" plus (+) to the plate of the last tube in any combination. Due to the low resistance of the phones or speaker as compared with the coupling resistances a much higher plate voltage is usually secured on the last tube resulting in a higher "B" battery drain and poorer reproduction.

You will need the following parts:

AFT—Type 285 (6 to 1 ratio) General Radio



audio-frequency transformer;
R1. R2 and R3—Code B Brach-stats;
J1 and J2—No. 66 Pacent filament-control jacks;
J3—No. 65 Pacent filament-control jack;
GC1 and GC2—fixed condensers .1 mfd.;
R4 and R5—coupling resistances .25 megohm;
GL1 and GL2—grid-leaks .5 megohm.

The constants given are for tubes of the 201-a type. For these tubes the second "B" battery marked 45-90-volts can be a 45-volt battery. This gives a total of 135 volts on the stages in which there is a coupling resistance in the output circuit.

If you want to get the maximum possible voltage amplification, two *high-mu* tubes should be used as the first tubes and a power tube in the last socket.

R1, R2 and R3 should be of the proper type to furnish the correct filament current to the respective tubes. Where the signals are quite loud it may be advisable to connect GL1 to one of the "C" batteries so that more bias is obtained. If the last tube is one of the new Radio Corporation power-type tubes the high negative bias recommended by them should be used.

Although operation on the first two jacks will not be quite as satisfactory when the phones are used it will be considerably better on the last jack when using the loudspeaker.

To get full advantage of the *high-mu* tubes R4 and R5 should be increased to about .5 megohm and the second "B" battery should be two 45-volt blocks. This voltage seems rather high but when it is remembered that the fraction of *mu* which is obtained per stage is proportional to the ratio of the external resistance to the sum of the tube and external resistances and that the plate resistance rises rapidly with decrease in plate voltage, it is clear that the "B" voltage has to be high to compensate for the drop in the higher coupling resistance needed.

What Is an Aperiodic Antenna?

QUESTION: I see the term "aperiodic" antenna coupling used frequently in radio articles, but I can find nothing about it in the radio books that I have. Will you explain what is meant?

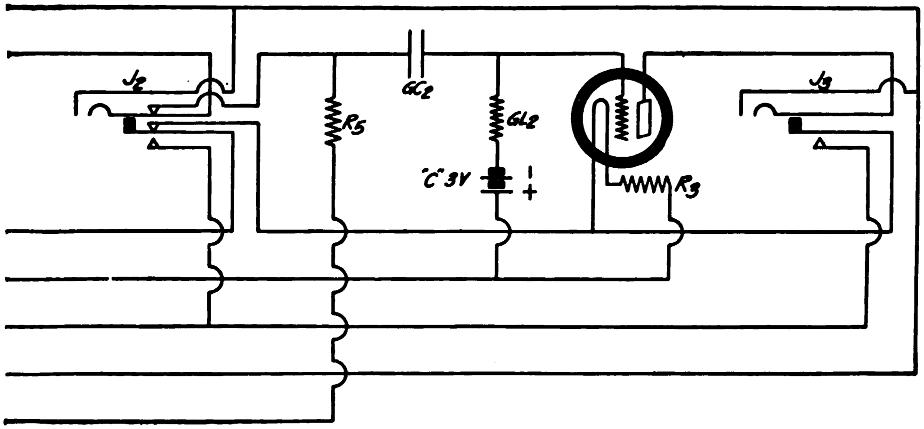
HOWARD THOMAS

ANSWER: The term aperiodic means "without period" or "dead beat." As applied to an electrical circuit this signifies that it has no resonant frequency. In a circuit containing capacity and inductance such as an antenna circuit this can only be secured by introducing a very high resistance in series. For absolute aperiodicity this resistance should be *infinite*. In practice this can be approached by using a few thousand ohms resistance.

The resistance of the average receiving antenna lies between about 25 and 100 ohms. This is obviously not enough to make the circuit aperiodic.

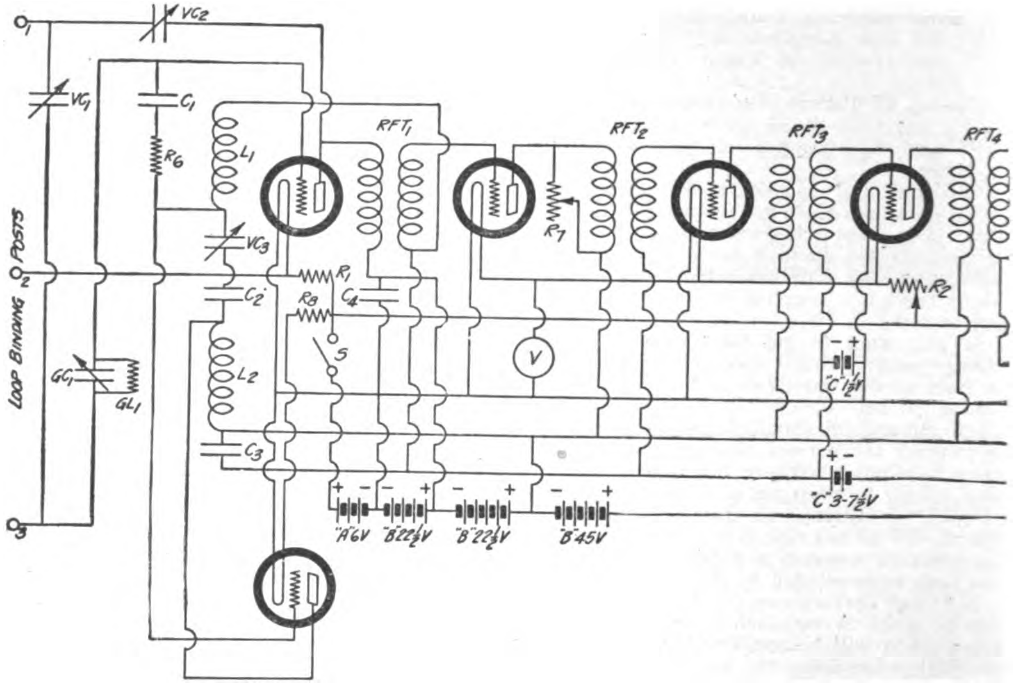
Actually in receivers using so-called aperiodic primaries the set is operated at frequencies well off the resonant frequency of the antenna circuit. This minimizes interaction between the antenna and secondary circuits and operation is somewhat analogous to that obtained with an aperiodic antenna.

When receivers that are designed to operate at the higher frequencies (shorter wavelengths, such as the amateur uses) are used on the usual antenna, the lack of aperiodicity is evident. At some setting of the receiver it will be difficult to make the circuits oscillate. Generally the coupling has to be loosened, the plate voltage increased, or feed back increased to maintain oscillations. This occurs at the resonant frequency of the antenna circuit and is due to the absorption of power by it, or what is equivalent to the introduction of resistance into the oscillating circuit. If the antenna cir-



AUTOMATIC VOLTAGE CONTROL ON A RESISTANCE-COUPLED AMPLIFIER

FIGURE 1: *This circuit diagram, using filament control jacks, shows a scheme for applying high plate voltage on all the resistance-coupled stages and a lower voltage on whichever stage the loudspeaker is operating.*



cuit were really aperiodic this would not occur.

A more accurate term to apply to this type of coupling would be "untuned." The term "semi-aperiodic" used by some authors also is more nearly the proper term.

The Circuit for Best's Superheterodyne

QUESTION: I would like to build Best's superheterodyne receiver for operation on a loop which will cover both the broadcasting and amateur wavelengths. Do you think a radio-frequency receiver would be as satisfactory? Can you give me the diagram for a receiver of either type?

HARRY HUNTER

ANSWER: To get satisfactory operation with a loop antenna the equivalent of three stages of radio-frequency amplification must be used. To get satisfactory selectivity the input to the first tube (the loop circuit) and one other stage of radio-frequency should be tuned. To cover the frequency band you wish to, a set of plug-in coils would have to be used which would unnecessarily complicate the construction and operation. We suggest you build the "Best's Modified Superheterodyne" which is designed to operate from 500 to 6,000 kilocycles (600 to 50 meters).

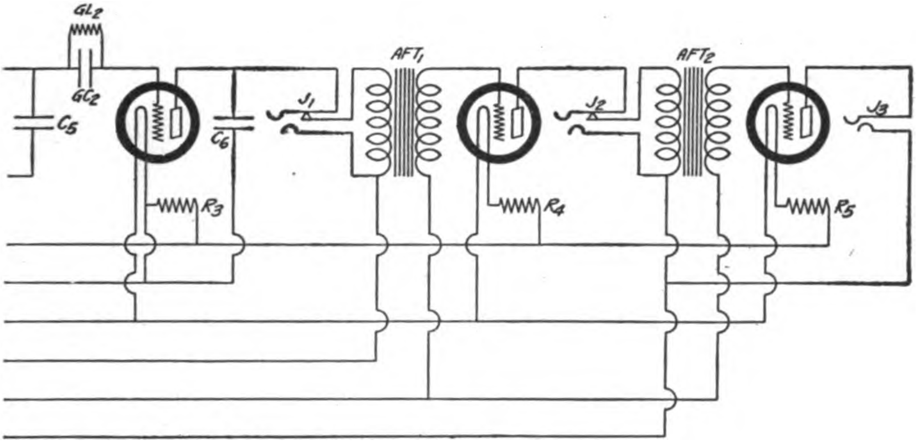
The complete diagram is given in Figure 2. You will need the following parts:

RFT1, RFT2 and RFT3—Intermediate frequency transformers, Remler No. 611, General Radio No. 271, or Silver untuned;
RFT4—Intermediate frequency transformer, Remler No. 610, General Radio No. 331, or Silver tuned;
AFT1 and AFT2—Audio-frequency transformers, General Radio, Karas, Pacent Superformer or Rauland Lyric;
R1, R3, R4 and R8—Automatic filament control cartridges, Amperite No. 1A;
R5—Automatic filament control cartridges, Amperite No. 112;
R2—Rheostat, 30 ohms;
R6—Grid-leak, .1 megohm;
R7—Potentiometer, 2,000 ohms, Federal or Centralab;
L1 and L2—Two windings of oscillator coils, General Radio No. 277-A, B and C:
VC1 and VC3—Variable condensers, .0005 mfd., any reliable make;
VC2—Variable condenser, .00005 mfd., XL Model G, Chelten or Continental:
C1 and C2—Fixed condensers, .006 mfd.;
C3—Fixed condenser, 2 mfd.;
C4—Fixed condenser, 1 mfd.;
C5—Fixed condenser, type recommended by manufacturer for RFT4;
C6—Fixed condenser, .002 mfd.;
GC1—Variable grid condenser, .00005 mfd., same as VC2;
GC2—Fixed grid condenser, with grid-leak mounting, .00025 mfd.;
GL1 and GL2—Grid-leaks, 3 megohm;
S—Filament switch.

In addition to this you will need 5 cushioned sockets for standard base tubes, 3 sockets for 199 tubes, an oscillator coil mounting, Gen-

THE CIRCUIT FOR BEST'S MODIFIED SUPERHETERODYNE

FIGURE 2: *The circuit is designed to tune from 500 to 6,000 kilocycles (600 to 50 meters). Plug-in coils are used to cover this wide frequency band.*



eral Radio No. 274-B and a panel type 0-6 V voltmeter.

UV-199 tubes are used in the three intermediate-frequency stages and standard base tubes in all of the others. The voltmeter permits regulation of the voltage applied to the UV-199 tubes. This voltage is controlled by R2.

When the manufacturers of the audio-frequency transformers specified manufacture transformers of two ratios, the higher ratio should be used in the first stage.

A loop with a mid tap should be used. Condenser VC2 controls regeneration in the loop circuit and should preferably be a small variable condenser which can be adjusted from the panel. If the regeneration control is not wanted the set should be tuned to a high frequency (short wavelength) and VC2 set just below the oscillating point.

Resistance R7 is a volume control. Only two of the connections on this potentiometer should be used. One of those used should correspond to the slider arm on the usual type. At the maximum resistance end it should be disconnected.

The capacity of C5 will depend on the type of intermediate frequency transformers used. This transformer should be a type designed to operate at the same frequency that the untuned ones are. Some manufacturers incorporate C5 in the transformer so no external condenser is needed. Others supply one of the proper value.

Condenser C2 is a fixed condenser which will prevent the full "B" battery voltage being applied to the tube filaments if the plates of VC3 are short-circuited. Its capacity is high enough so it has little effect on the tuning of VC3.

The values of GL1 and GL2 will vary slightly with different tubes and several values should be tried.

The Amperite specified for the last tube is designed to supply .5 ampere. This is the filament consumption of the UX-112 tube which should be used in this stage for best results. If a UV-201-a tube is used the standard .25 ampere Amperite should be used.

The four leads going to L1 and L2 should be connected to the plugs of the oscillator coil mounting. By plugging in the different coils the different frequency ranges can be covered. If no signals are received the connections to either L1 or L2 should be reversed (not both).

If the oscillator dial tunes broadly the value of R6 should be increased to .25 or .5 megohm.

Although one loop can be used for the whole frequency range this is not very satisfactory as two sets of taps on each side of the mid tap have to be used. For the range from 50 to 150 meters a special loop should be used. Use four turns on a 30-inch square frame with a mid tap.

The Proper Size of Coupling Condenser

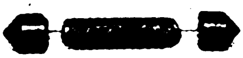
QUESTION: I have a resistance-coupled audio-frequency amplifier made up with the ordinary resisto-coupler which holds the condenser and two grid-leaks. Could the quality of the music received be improved in any way? Some of the lower musical notes seem to be faint.

A. M. CLAYTON

ANSWER: If your set is made up as usual the coupling condenser in your resisto-coupler is no doubt of the .006 mfd. size. Try adding an external condenser (either one of the small .02 mfd. mica condensers or .1 to .5 mfd. paper condensers) in parallel to the original coupling condenser. This should increase the volume of the lower notes.

WHAT'S NEW IN RADIO APPARATUS

THIS *department is conducted by* POPULAR RADIO LABORATORY *for the purpose of keeping the radio experimenter and the broadcast listener informed concerning the newest inventions and the approved developments in radio equipment. Only such apparatus as has been tested and endorsed by the Laboratory is noted in these columns.*



A metallized filament resistor that gives a permanent and uniform resistance for use in receiving sets.

A NEW TYPE OF RESISTANCE

Name of instrument: Resistance unit.

Description: This is a new type of resistance that can be used in resistance-coupled amplifiers or in any other place in the receiving set where a fixed non-varying resistance is necessary. It is made by a new process that embraces coating a glass filament with a metallic covering of the prescribed resistance. The unit fits in any of the standard resistance mountings or grid-leak mountings.

Usage: In any part of an electric circuit where a fixed resistance carrying only a small load is required.

Outstanding features: Small size. Neat appearance. Accurate values. Small variation with voltage.

Maker: Durham & Company.

AN EXCELLENT VERNIER DIAL

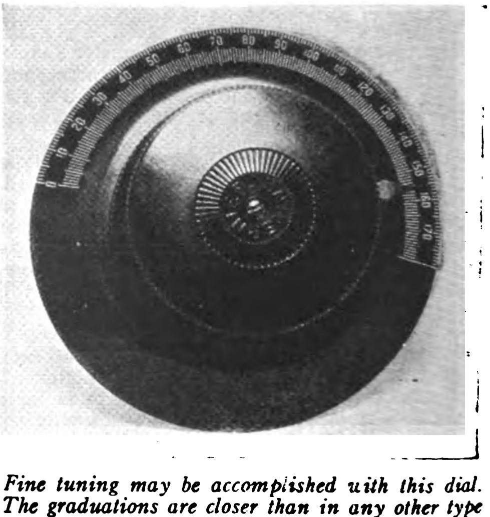
Name of instrument: Vernier dial.

Description: This instrument, which goes by the trade name of Univernier, consists of a fixed scale which is graduated in 180 degrees and contains a finer mark adjustment than those now prevalent on the market. It is equipped with a gear train that gives a high ratio of instrument revolution to dial revolution. It is equipped with a pointer and a large knob, which makes it possible for the eperator to see at a glance the setting for tuning in given stations. There is also furnished with this dial a small semicircular slip that fastens in the edge along the graduated circumference of the dial for marking down the station wavelengths as they are desired. This slip of good quality cardboard is large enough to accommodate the call letters of all the stations a set is capable of picking up. The stations are marked down and connected with a pencil mark on the dial setting where they tune in.

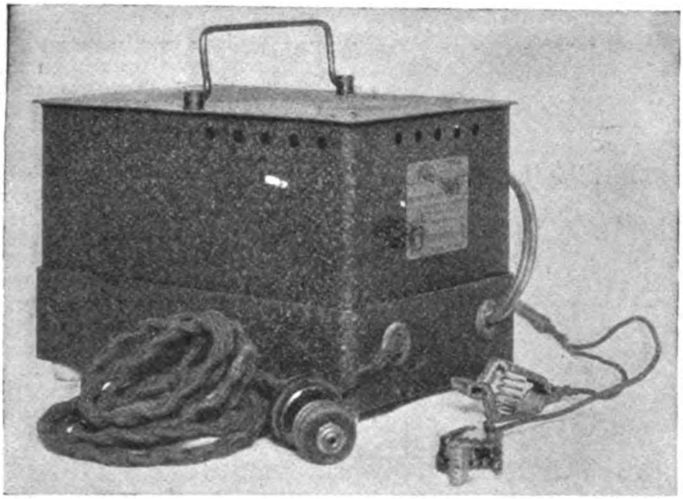
Usage: In any receiver for controlling the revolution of the instruments that produce tuning.

Outstanding features: Neat in appearance. Accurate adjustment. Capable of logging.

Maker: Walbert Mfg. Co.



Fine tuning may be accomplished with this dial. The graduations are closer than in any other type of tuning control.



Here is a charger that gives full-wave rectification.

AN EFFICIENT BATTERY CHARGER

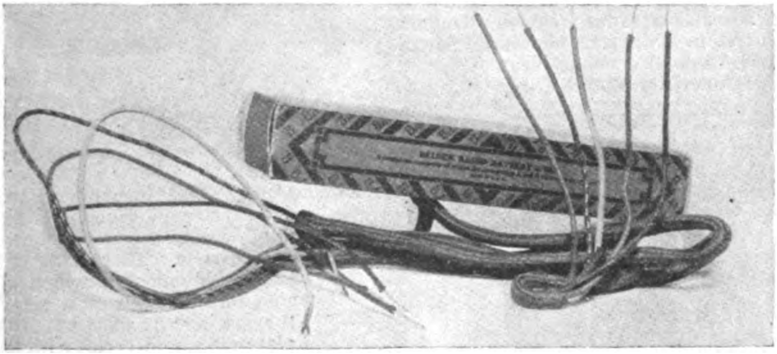
Name of instrument: Battery charger.

Description: This device is known by the trade name of Ful-Wave Battery Charger. It is unique in that it applies a more continuous current to the battery than the ordinary type of half-wave rectifier. It contains the necessary transformer and tube rectifying apparatus to apply both halves of the cycle in the form of a unilateral current to the battery that is to be charged. It is entirely enclosed in a metal case with suitable vent holes for cooling. It is equipped with a plug for screwing into a lamp socket and also with two battery terminals that are to be clipped on to the battery during charge.

Usage: In connection with a storage battery for recharging.

Outstanding features: Supplies a more continuous current to the battery. Quick in operation. Well made. Good appearance.

Maker: Liberty Electric Corp. of New York.



This cord will enable you to make neat connections to your receiver.

A MULTIPLE BATTERY CABLE

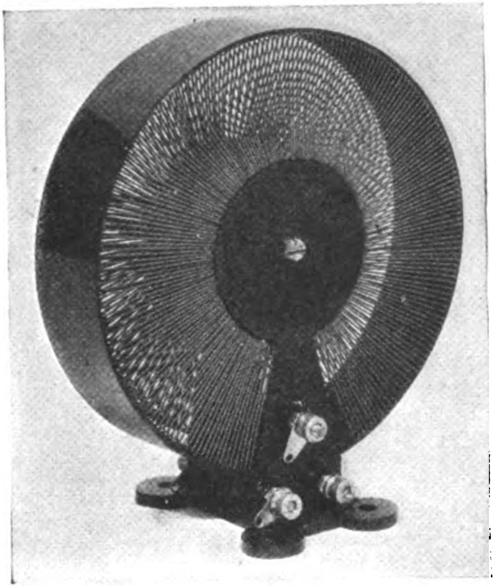
Name of instrument: Battery cable.

Description: This cable contains five different wires, each insulated with rubber and braided insulation of different colors for the "A" battery connection to the receiver and also for the "B" battery connection. It is covered with an "over-all" braid which assembles the five wires on one cable, thus making a very neat method for installation of a receiving set in the home. This article is packed in an attractive carton and is known in the trade as the Belden Radio Battery Cord.

Usage: In connection with the batteries for furnishing the "A" and "B" current to a receiver.

Outstanding features: Suitably insulated. Flexible. Neat in appearance. Easy to install.

Maker: Belden Mfg. Co.



An air-spaced toroid.

A NEW TYPE OF COIL

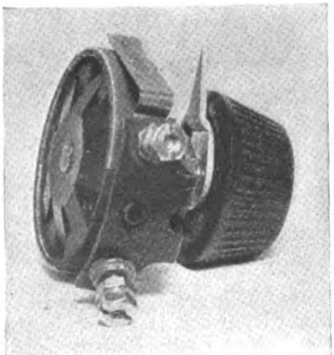
Name of instrument: Radio-frequency coil.

Description: This coil is wound with a square cross section embracing the popular toroid shape. It is unique in that the windings are air spaced and only touch the insulating material at the outer periphery and at the inner support which contains the binding posts for connections as well as serving as a base for attaching to the baseboard of a set.

Usage: In a set as a radio-frequency coupler.

Outstanding features: Space winding. Air dielectric. Confined field. Neat.

Maker: All-American Radio Corp.



Compact and reliable.

A RELIABLE RHEOSTAT OF EXTREMELY SMALL SIZE

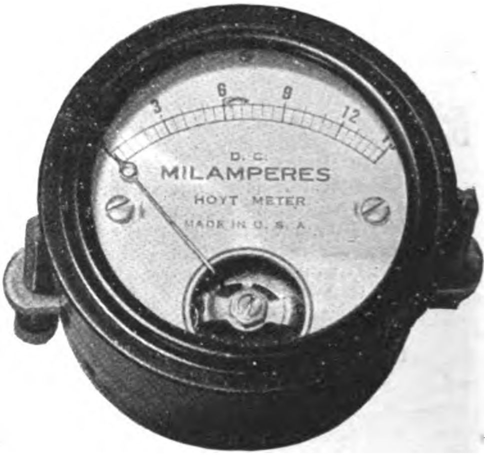
Name of instrument: Filament rheostat.

Description: This rheostat is made in very small form. It contains a resistance element that is wound on a flexible strip of insulating material which is held fast in a novel manner on the outside of a revolving disc. Contact is made in the same efficient manner as with previous rheostat controls manufactured by the same company. As the resistance element revolves its outer surface makes contact with a flexible arm which is attached to one of the binding posts. The other end of the resistance element is attached to the remaining binding posts. A neat knob and pointer is all that would be seen from the front of the panel when the rheostat is mounted in a receiving set.

Usage: In a set as a filament control.

Outstanding features: Extremely small size. Reliable operation. Good workmanship. Neat appearance.

Maker: Cutler-Hammer Mfg. Co.



No screws are required to mount this instrument.

A PLATE MILLIAMMETER OF SMALL DIAMETER FOR PANEL MOUNTING

Name of instrument: Direct current milliammeter.

Description: This instrument, which contains a full size movement, is arranged in a small case for mounting on receiving panels. It has a scale reading of from zero to to 15 milliamperes, which makes it suitable for use with most receivers now on the market. It may be connected in the plate circuit in series with the "B" batteries to tell the total amount of current that the set is drawing. In mounting in the hole drilled for it on the panel there are two set screws that are furnished with the instrument which are used to draw the front flange up tight against the panel without drilling extra holes or without the use of external unsightly screws in the panel.

Usage: In a receiving set for measuring the total plate current.

Outstanding features: Small size. Neat appearance. Ease in mounting. Reliable.

Maker: Hoyt Electrical Instrument Works.

A CONDENSER WITH TWO SETS OF SQUARE MOVING PLATES

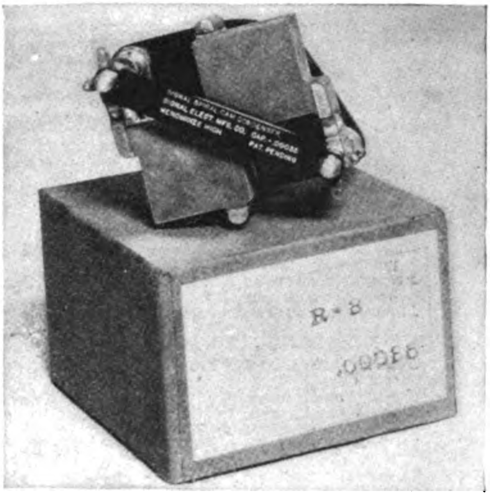
Name of instrument: Variable condenser.

Description: This condenser is mounted on a piece of bakelite which supports two shafts on which the movable elements pivot. The knob controls a cam which rotates in a grooved slot in the bakelite for obtaining the curve form desired for eliminating crowding of the lower wavelength stations in broadcasting. The trade name for the instrument is the Signal Spiral-cam Condenser.

Usage: In any radio-frequency circuit for tuning.

Outstanding features: High efficiency. Compactness. Low minimum capacity. Simple to mount on panel. Ease in tuning.

Maker: Signal Electric Mfg. Co.



A new type of condenser that contains two sets of movable plates and makes tuning easy at the lower frequencies.

A DIAL OPERATED BY PLANETARY ROLLERS

A vernier dial with no "back-lash."

Name of instrument: Vernier knob and dial.

Description: This knob is made in bakelite with either a black or a mahogany finish and consists of two tuning controls—one being the regular control and the other being a very smooth-action vernier. The dial itself is held on the shaft of the instrument which is used to control by means of a set screw. The action obtained with the vernier is exceptionally even and free from any kind of "back-lash." A suitable adjusting nut of bakelite is attached on the front of the dial, concentric with the shaft, which may be adjusted for applying the proper tension to the rollers for instruments that turn easily or with some friction. The trade name is "Fynur."

Usage: As a dial for tuning radio-frequency circuits.

Outstanding features: Neat appearance. Fine vernier action. No "back-lash." Clear vision of the numerals.

Maker: August Goertz & Co., Inc.

A NEW RESISTANCE ELEMENT

Name of instrument: Fixed resistance.

Description: This unit is built up of a bakelite base in which is mixed a graphitic solution material for the resistance element. It is molded in shape between two terminals that fit the ordinary resistance mounting or it may be soldered directly to the wires that connect it electrically in the circuit by inserting the wires in the hole at each end of the unit. It is known in the trade as a "Bradleyunit."

Usage: In any place in an electric circuit where a fixed high resistance of small carrying capacity is necessary.

A reliable type of resistance unit.

Outstanding features: Compact. Uniform. Not affected greatly by temperature. Accurate within reasonable limitations.

Maker: Allen-Bradley Co.

Apparatus Approved by Popular Radio

This list of apparatus approved by the POPULAR RADIO LABORATORY will be continued as a part of the WHAT'S NEW IN RADIO APPARATUS department until all instruments, parts and complete sets have been included. The listing is alphabetical by manufacturer's name and the installment in this issue includes only the letters S and T.

AERIALS

Balloon aerial (for amateur experimental purposes only); Everett Scanlon.
Springfield stranded braided antenna wire; Springfield Wire & Tinsel Co.
Super-antenna; Super-Antenna Co.

AUDIO-FREQUENCY TRANSFORMERS

Samson helical-wound transformer; Samson Electric Co.
Giblin audio-frequency transformer; Standard Radio & Electric Co.
"States" transformers; The States Co.
"Sterling" audio-frequency transformer; Sterling Mfg. Co.
"Superior" audio-frequency transformer; Superior Products Mfg. Corp.
Thordarson super audio-frequency transformer; Thordarson Elec. Mfg. Co.
Thordarson interstage power amplifying transformer; Thordarson Elec. Mfg. Co.
Thordarson autoformer; Thordarson Elec. Mfg. Co.

BATTERIES

Sidbenel "B" batteries (wet); Sidbenel Electric Co.
"Twin" dry batteries; Twin Dry Cell Battery Co.

BINDING POSTS

Snap-on binding post; Snap-On Electric Co.

CRYSTAL DETECTORS

Silvertone crystal detector; Silvertone Crystal Co.
Sensitive cartridge detector; Stafford Radio Co.
Radetec fixed detector; Towner Radio Mfg. Co.

DIALS

Visidials; Harold M. Schwab, Inc.
Dial; Trufix Radio Products Co.

FIXED CONDENSERS

"Sangamo" mica fixed condenser; Sangamo Electric Co.
"Schindler's" build-up mica condenser (can be taken down and varied); Chas. Schindler.
Fixed condenser; Stafford Radio Co.

GRID-LEAKS AND RESISTANCES

Resistron; Temple Instrument Co.
"Turn-it" adjustable grid-leak; Turn-it Radio Sales, Inc.

HEADPHONES

Deveau Gold Seal headset; Stanley & Patterson.
"Tower's" scientific headset; Tower Mfg. Co.
Ambassador phones; Tower Mfg. Co.
"Little Spitfire" headset; Tower Mfg. Co.
Berwick Supreme headphones; Triangle Electric Trading Co.
"Trimm" headset; Trimm Radio Mfg. Co.
Professional headset; Trimm Radio Mfg. Co.
Dependable headset; Trimm Radio Mfg. Co.

INSULATORS

"Stormproof" insulator; Stormproof Corp.

JACKS

"Saturn" jack; Saturn Mfg. & Sales Co., Inc.
Radjo anti-capacity jacks; Sharpe Spark Plug Co.

KITS

Samson super-kit; Samson Electric Co.
De Luxe neutrodyne kit; Harold M. Schwab, Inc.
"Shamrock" kit (tuned radio-frequency); Shamrock Mfg. Co.
Silver superheterodyne kit; Silver-Marshall, Inc.
Sypher ultradyne kit; Sypher Mfg. Co.

LIGHTNING ARRESTERS

Simplex lightning arrester; Simplex Radio Co.

LOOPS

Volumax loop; Scott & Fetzer Co.
Hexloop; Scribner Co.
Silver collapsible center-tapped loop; Silver-Marshall, Inc.
"Key to the air" cage antenna; Stafford Radio Co.

LOUDSPEAKERS

"Sheltone" loudspeaker; Sheltone Co.
"Timbretone" loudspeaker; Timbretone Mfg. Co.
"Timbretone" loudspeaker (cabinet type); Timbretone Mfg. Co.
Timmons Talkers; J. S. Timmons.
"Little Spitfire" loudspeaker; Tower Mfg. Co.
Tower's Scientific loudspeaker; Tower Mfg. Co.
Berwick Supreme loudspeaker; Triangle Electric Trading Co.
Concert model speaker; Trimm Radio Mfg. Co.
Homespeaker; Trimm Radio Mfg. Co.
Trinity loudspeaker; Trinity Radio Corp.

MISCELLANEOUS ACCESSORIES

Safe-guard insulation; Safe-guard Insulation Co.
Battery connector; H. B. Sherman Co.
Extension connector; H. B. Sherman Co.
Somerville terminal tags; Somerville Radio Stores.
Universal coil winding machine; Specialty Automatic Machine Co.
Steinite interference eliminator; Steinite Laboratories.
Steinmetz amplifier for crystal sets; Steinmetz Wireless Mfg. Co.
Sterling home tube tester; Sterling Mfg. Co.
"Lastite" (soldering terminals); Wm. Stevens Co.
Insurtube; Terle Electric & Mfg. Co.
Wire nuts; Tork Co., Inc.

PANELS

Spaulding bakelite-duresto; Spaulding Fibre Co., Inc.
Celesto shadow black panels; Triangle Rubber & Supply Co.

PHONE PLUGS

"Saturn" automatic plug; Saturn Mfg. & Sales Co., Inc.

PHONOGRAPH ATTACHMENTS

Dulce-Tone; Teagle Co.
Trimm phonograph attachment; Trimm Radio Mfg. Co.

RADIO CABINETS

Salisbury radio tables; Salisbury Bros. Furniture Co.
Radio cabinets and furniture; Southern Toy Co.
Glass cabinets; Steffen Glass Cabinet Co.

RADIO-FREQUENCY TRANSFORMERS

Radio-frequency transformers; Sangamo Electric Co.
Silver radio-frequency transformer unit; Silver-Marshall, Inc.
Giblin radio-frequency transformer; Standard Radio & Electric Co.
Sterling radio-frequency transformer; Sterling Mfg. Co.
Sterling intermediate-frequency transformer; Sterling Mfg. Co.
Summit toroidal transformers; Summit Radio Mfg. Co., Inc.
Matched superheterodyne transformers; Sypher Mfg. Co.
Ultradyne transformer; Sypher Mfg. Co.

RECEIVING SETS

Brunswick De Luxe Ambassador receiver; Harold M. Schwab, Inc.

Service receivers; Service Radio Co.
Thermiodyne radio receiver; Shepard-Potter Co., Inc.
"Shepco" "All Purpose" receiver; Shepard-Potter Co.
Silver superheterodyne receivers; Silver-Marshall, Inc.
Silverset receiver; Silverset Radio Co.
Simplex SR-r receiver; Simplex Radio Co.
Giblin Radiocar receiver; Standard Radio & Electric Co.
Standardyne receiver; Standard Radio Corp.
7-tube superheterodyne receiver; Stanwood Electric Specialty Co., Inc.
Thermiodyne receiver; Thermiodyne Radio Corp.
Thompson neutrodyne receiver; R. E. Thompson Mfg. Co.
Thompson 5-tube neutrodyne knockdown set; R. E. Thompson Mfg. Co.
Sectional "Universal" radio outfits; Tresco Radio.
"Tuska" receivers; C. D. Tuska Co.

RHEOSTATS

Filament rheostat; Sterling Mfg. Co.

SOCKETS AND ADAPTERS

Silver 5-gang No. 199 socket; Silver-Marshall, Inc.
Dulce-Tone (phonograph adapter); The Teagle Co.

SWITCHES

"Saturn" battery switch; Saturn Mfg. & Sales Co., Inc.
Radjo anti-capacity switch; Sharpe Plug Co.

TESTING INSTRUMENTS

Filament meter; Sterling Mfg. Co.
Panel type meter; Sterling Mfg. Co.
Pocket type meter; Sterling Mfg. Co.

TOOLS AND EQUIPMENT

Samson electric soldering iron; Samson Cutlery Co.
"Bernard" hand-vise pliers; Wm. Schollhorn Co.
"Kant Stick" hydrometer; Scranton Glass Instrument Works, Inc.
Scranton hydrometer; Scranton Glass Instrument Works, Inc.
Ayanbee hydrometer; Scranton Glass Instrument Works, Inc.
Spintite wrenches; Stevens Co.
Stevens speed-up tools; Stevens Co.
Stevens panel cutter and bezel beader; Stevens & Co.
Stevens combined drill and countersunk; Stevens & Co.

TUBES

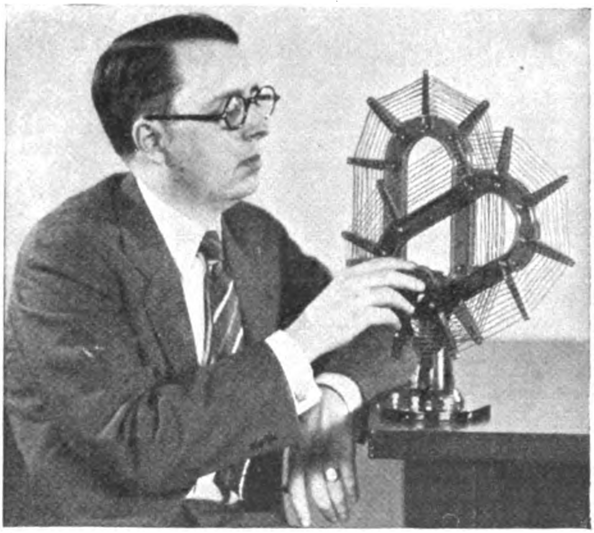
"Schickerling" tubes; Schickerling Products Mfg. Co.
Aerodyn tube type 201-a; Star Engineering Co.
"Comet" vacuum tube; Summit Radio Co.
Claritron tube, type 201-a; Superior Radio Co.
Supertron radio tubes; Supertron Mfg. Co.

TUNING INDUCTANCE UNITS

Samson oscillator coupler; Samson Electric Co.
Oscillator coil unit; Sangamo Electric Co.
"Kay" coils; R. C. Schoonhoven.
"Shamrock" variocoupler; Shamrock Mfg. Co.
"Radjo" low-loss tuner; Sharpe Spark Plug Co.
"Shepco" all-wave coupler; Shepard-Potter Co., Inc.
Sickles diamond weave inductance coils; F. W. Sickles Co.
Sickles variometer; F. W. Sickles Co.
Sickles variocoupler; F. W. Sickles Co.
Sickles tuned transformer coil; F. W. Sickles Co.
Sickles knockout coil; F. W. Sickles Co.
Sickles coils for Roberts' circuit; F. W. Sickles Co.
Sickles coils for Craig reflex; F. W. Sickles Co.
Silver oscillator coupler; Silver-Marshall, Inc.
Silver coupling unit; Silver-Marshall, Inc.
Simplex variocoupler; Simplex Radio Co.
Simplex DX tuner; Simplex Radio Co.
Kelcoil; Syco Radio Products Corp.
Oscillating coil; Sypher Mfg. Co.
Tuning coil; Sypher Mfg. Co.

VARIABLE CONDENSERS

Silver low-loss condenser; Silver-Marshall, Inc.
Microdenser; Sterling Mfg. Co.
Thordarson variable condenser; Thordarson Electric Mfg. Co.



Kadel & Herbert

A NOVEL VARIOMETER LOOP

A new variometer loop antenna which consists of two semi-elliptical coils, one of which may be rotated in a plane at right angles to its axis so that the inductive relation may be varied continuously, has been designed by Stewart C. Whitman, who is pictured above adjusting the knob that tunes the instrument. This loop may be used with a fixed shunt capacity instead of the usual variable capacity unit.

Conducted by Dr. E. E. Free

The Einstein Theory Confirmed Once More

Of the three tests originally proposed to determine the truth of the Einstein theory of relativity one was the alteration of the wavelength of light rays originating on the sun. According to Einstein light is affected by gravity. One of the other two tests, you remember, was the bending of the rays of starlight by the intense gravitational attraction of the sun. The wavelength alteration is another gravitational effect. The intense gravitational attraction at the surface of the sun affects the hot atoms of hydrogen and other gases there. The light waves which these atoms omit are slightly longer than similar waves omitted by the same kinds of atoms on earth, where gravity is less intense.

This wavelength test for the Einstein theory was applied to sunlight by Dr. St. John of Mount Wilson Observatory. His results confirmed the theory, although the proof turned out not to be absolute. Some necessary corrections were introduced and a few possible uncertainties came in with them. Now the same test has been applied to a much more striking instance, the light from the tremendously heavy companion star of Sirius. Again the work comes from the Mount Wilson Observatory and is reported in a paper by Dr. Walter S. Adams, the Director of that observatory!

This star called Sirius is the brightest fixed star in the sky. To the eye it seems a single star. Astronomers have discovered, however, that it really is two stars. They revolve about each other in some fifty years, much as the earth revolves about the sun. The fainter of the two stars is believed to have an astounding density. Professor Eddington, the great English astronomer, has estimated that the matter of this star may weigh more than 4,000 times as much as the same volume of lead.

Naturally the force of gravity on so dense a star will be far more intense than on the surface of our sun. The shift of the wavelengths of the light rays, as required by the Einstein theory, will be correspondingly greater. Calculations indicate, in fact, that this shift in the light from the Sirius companion ought to be about thirty times as great as the analogous shift in light rays from the sun.

The exact determination of the wavelength shift in the Sirius light was not easy. The light rays from the faint companion star are difficult to separate from those originating on the much brighter disk of Sirius itself.* But, using the great 100-inch telescope at Mount Wilson, Dr. Adams overcame these difficulties. The expected shift of the wavelengths was detected. It corresponds with the amount predicted from the Einstein equations. And so, the famous theory has passed successfully another test.

Electrons Leave Filament as They Should

Many years ago the great British physicist, James Clerk Maxwell, worked out what has come to be known as Maxwell's Law for the formulation of events which happen by chance. For example, this law states the number of molecules of a gas which will have high speeds, the number which will have low speeds and the number which will have moderate speeds; all at any given instant and at a determined temperature and pressure. Electrons in a vacuum tube behave in many ways as do the flying molecules of a gas, and Maxwell's Law has been applied, also, to the calculation of many of the rules which control the behavior of the electron population in such a place as a radio vacuum tube.

The same law has been applied, furthermore, to the escape of the electrons from the filament. Many filament calculations are based, implicitly or explicitly, on this famous principle. Experiment has confirmed it, so far as the experiments were accurate, but it has been felt that they were not accurate enough. Recently Mr. L. H. Germer, of the Bell Telephone Laboratories, has repeated the experimentation with extreme care and with every possible refinement.* The electrons are well-behaved. Maxwell's Law is obeyed; the respective percentages of speedy, slow and moderately fast electrons leaving the filament in any instant are just what the Maxwell calculations indicate that they ought to be.

---

* "The Relativity Displacement of the Spectral Lines in the Companion of Sirius," by Walter S. Adams. *Proceedings of the National Academy of Sciences* (Easton, Pa.), vol. 11, pages 382-387 (July, 1925).

To the radio expert the chief value of this result will be an increment of peace of mind. We have been assuming certain things about electrons; that they are tiny separate charges of electricity, that they can collide and rebound much as tennis balls would, that they escape from a hot filament in somewhat the same way in which water molecules evaporate from an exposed surface. Gradually we have grown to think of these assumptions as facts, although no one of us has ever seen an electron nor can make even the wildest guess as to what it would look like if we could see it. And so, it is consoling to discover that a piece of extremely careful measurement on electrons shows that they really do behave, in this instance at least, in the way which we have been assuming for them.

---

*"The Distribution of Initial Velocities Among Thermionic Electrons," by L. H. Germer. *The Physical Review* (Corning, N. Y.), vol. 25, pages 795-807 (June, 1925).

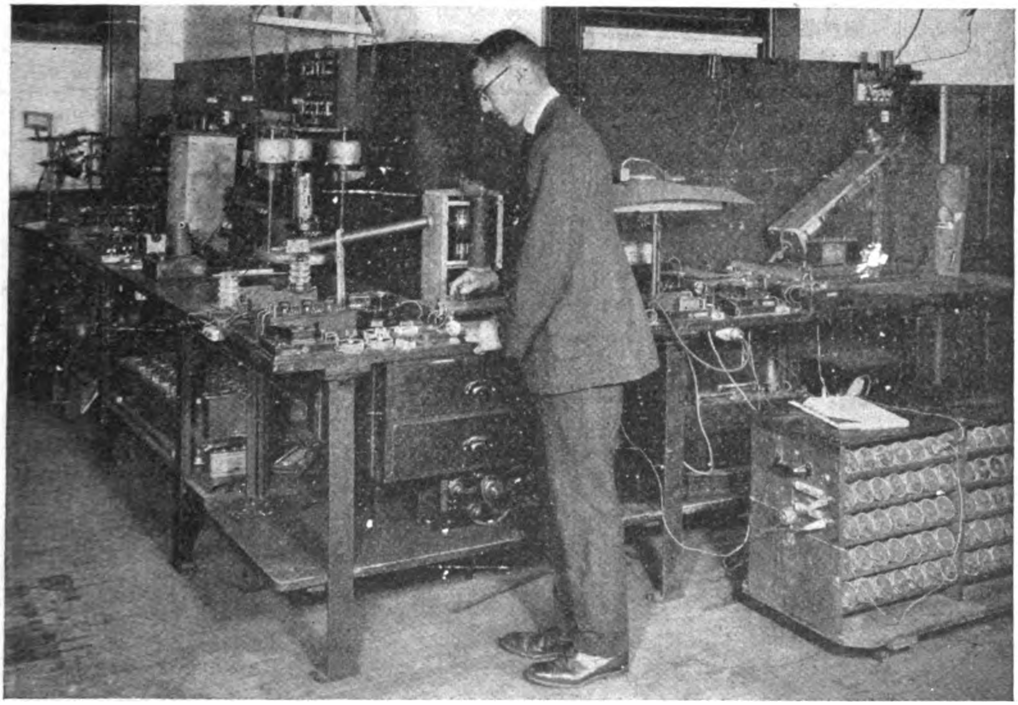
Inspecting Motors by Radio

Every radio listener knows that a radio set will pick up and make annoyingly audible the electromagnetic disturbances sent out by motors which have imperfect brushes or are otherwise not in good condition. Many a fan has complained about the elevator motors in his apartment house, often to the actual advantage of the landlord, who did not know that he was wasting costly current for want of a little adjustment of his motor brushes. Now this same tendency of bad motors to broadcast radio noise has been put to practical use by Mr. John O. Gerson of the street railway company of Charleston, S. C.*

By arranging an antenna wire parallel to the track along which the cars are run and connecting this antenna to a special listening set, Mr. Gerson was able to hear the noises produced by the motors and to determine, in many instances, incipient faults of adjustment before these faults became noticeable to the motorman. The inclusion of simple tuning devices permitted the listener to distinguish between the normal hum of the motor and the high-frequency hiss of an arcing brush.

---

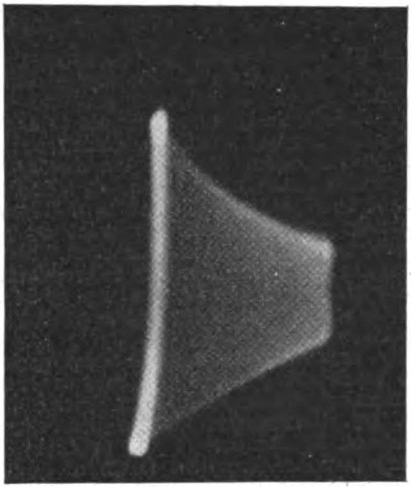
*"Radio Used to Discover Electrical Defects in Cars," by John O. Gerson. *The Electrical Railway Journal* (New York), vol. 66, page 90 (July 18, 1925).



Bell Telephone Laboratories

HOLDING A STOP-WATCH ON ELECTRONS

Mr. L. H. Germer, of the Bell Telephone Laboratories, has studied with the maximum possible accuracy the speeds of the electrons given off from a hot filament, like the filaments of radio vacuum tubes. Some of these electrons are very fast, others are relatively slow. The percentages of slow ones and fast ones agree with the theories worked out in advance.



A RECORD OF THE ELECTRON GUN

This picture shows how the end of the electron pencil, where it strikes the glass end of the tube, vibrates under the influence of an alternating magnetic field.

It seems probable that a special, portable receiver, properly equipped to tune in, in turn, different frequency bands, would be a useful inspection instrument, not only in the street railway industry, but to all users of many electric motors. Here is a problem for radio amateurs, one which it might be well worth while financially for some one to solve by devising a dependable and convenient standard hook-up for motor-inspection purposes.

A New Electron Gun

ONE of the well-known instruments for studying the oscillations of radio circuits is the Braun tube or electron oscillograph.* In this device a narrow stream or "pencil" of flying electrons is deflected to one side or the other by the voltages of the oscillating circuit. This electron pencil strikes against a flattened end of the tube. This end being coated with a chemical which gives off light under electron bombardment. Where the electrons strike, a glowing spot appears on the tube. As the pencil swings back and forth in time with the oscillations of the circuit, this spot is spread out into a line or curve. Thus one obtains the oscillograph records which are used to determine the modulation of broadcasting stations and to study the multitudinous properties of radio circuits and instruments.

This instrument has now been so modified that not only the glowing spot at the end of the tube is visible, but also the beam of electrons itself. The electron pencil shines visibly as it passes along the tube, much as though it were a beam of light. A more exact analogy is the visible track produced by a stream of tracer bullets fired from a machine gun, each bullet leaving its trace of smoke and flame as it flies through the air. Just so the electrons shot from the new "electron gun" leave a glowing track in the gas inside the tube.

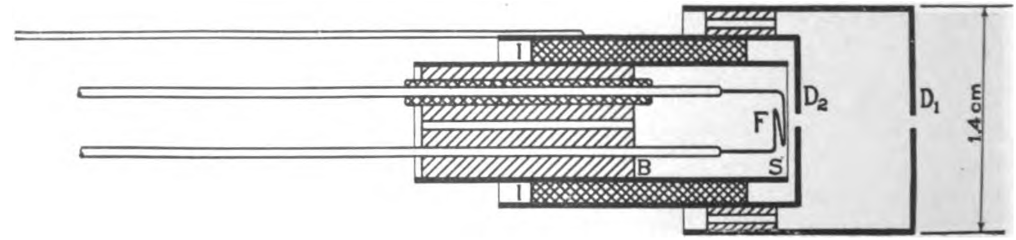
The new instrument is the invention of Professor J. W. Buchta, of the Department of Physics of the University of Minnesota.† It differs from the ordinary Braun tube mainly in containing a little mercury vapor. It is this vapor which renders the electron beam visible. Electrons are given off from a hot filament, just as in the ordinary radio tube. An applied voltage drives these electrons through holes in two metal diaphragms, thus producing the electron stream. This is the "gun" part of the apparatus. The electrons then encounter free atoms of mercury, flying around inside the tube. Some of these atoms are disrupted by the flying electrons. They then give off light. Thus the visible beam is produced.

Any beam of electrons is easily deflected by electrostatic or magnetic forces, but the beam of Professor Buchta's device is especially readily moved in this way. A permanent magnet held near the tube will bend the beam through a considerable angle. Even the effect of the earth's magnetism is evident when the

---

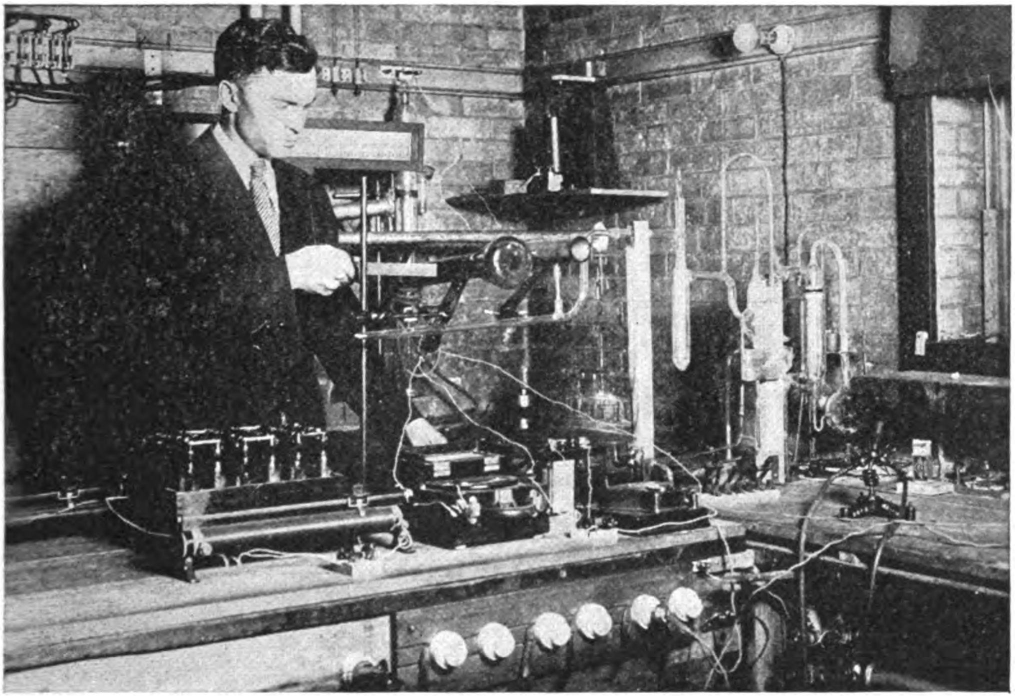
*For a description of this instrument see "The Electron Pencil for Studying Radio Circuits," by Paul Findley, POPULAR RADIO, for April, 1924, pages 328-334.

†"A Low-voltage Electron-beam Oscillograph," by J. W. Buchta. *Journal of the Optical Society of America* (Manesha, Wis.), vol. 10, pages 581-590 (May, 1925).



HOW THE ELECTRON GUN IS PUT TOGETHER

F is the hot filament from which the electrons escape. D_1 and D_2 are diaphragms, each with a small hole, these holes confining the escaping electrons to a single straight pencil. The first diaphragm is positively charged, to pull the electrons away from the filament. B is a metal block. The doubly crosshatched portions of the diagram represent glass tubes, used for insulation.



From a photograph made for POPULAR RADIO

PROFESSOR BUCHTA'S ELECTRON GUN IN ACTION

The oscillograph tube, into which the electrons are fired, projects toward the front, just at Professor Buchta's left. The gun itself is in the rear. Professor Buchta is holding a bar magnet, by which the visible stream of electrons inside the tubes may be deflected to one side or the other, depending on the pole of the magnet which one uses. At the right is the pump used to maintain the necessary vacuum in the tube.

tube is moved from a north-and-south position to an east-and-west position. Like other forms of electron-beam oscillograph, the instrument has practically no lag and almost no inertia. It responds instantly to alterations in the electric or magnetic forces affecting it.

Its greatest value will probably lie, however, in the visibility of the electron pencil through the tube. Professor Buchta states that the characteristics and utility of the instrument as a radio-frequency oscillograph are now being investigated. The possibility of actually seeing, instantly and directly, what is happening to the stream of bullets from the electron gun ought to give the device important value in many radio investigations, as well as in studies of magnetic and electric effects in other fields of science.

Do Impurities Improve Crystal Detectors?

AN important contribution to the much-discussed question of the theory of crystal detection was made a short time ago by Dr. Edgar T. Wherry, the distinguished mineralogist, now connected with the Bureau of Chemistry, in Washington.* Dr. Wherry examined a large number of mineral species of the most varied chemical composition. A number were found to have some value as detectors and some of these were found to vary from good to bad depending upon the amount of impurity in the crystal. Zincite, for example, is better the purer the crystal. But galena and pyrite reverse this behavior. Pure crystals do not detect well. Impure crystals, containing atoms of other elements built into the crystal structure, sometimes form the best detectors.

To explain his results, as well as the many other puzzling facts about crystal detection, Dr. Wherry suggests that the property of one-way conduction which characterizes good detector crystals may be related to an internal atomic structure such that the electrons are held in place by slightly unbalanced forces. They find it possible to move more freely in one direction (with relation to the crystal axis) than in the reverse direction. The effect of impurities may be, Dr. Wherry thinks, to distort slightly the atomic framework of the crystal, so that this one-sided holding of the electrons to their places comes into play.

What theory of crystal detectors will prove to be correct only time and more experiments will determine. Meanwhile, experimenters will find in Dr. Wherry's tables, reprinted on the next page, what is probably the most complete list of detector minerals compiled to date.

---

* "Radio-Detector Minerals," by Edgar T. Wherry. *The American Mineralogist* (Menasha, Wis.), vol. 10, pages 28-31 (February, 1925).

GOOD DETECTORS

Artificial Silicon	Si
Impure pyrite, iron sulphide	FeS_2
Tennantite, iron-copper arseno-sulphide	$Fe_2Cu_{10}As_4S_{13}$
Enargite, copper arseno-sulphide	Cu_3AsS_4
Artificial zinc oxide (zincite), pure	ZnO
Impure galena, lead sulphide	PbS

FAIR DETECTORS

Graphite, carbon	C
Artificial carborundum, silicon carbide	SiC
Octahedrite, titanium oxide	TiO_2
Brookite, also titanium oxide	TiO_2
Molybdenite, molybdenum sulphide	MoS_2
Pyrolusite, manganese oxide	MnO_2
Pyrrhotite, iron sulphide	FeS (variable)
Loellingite, iron arsenide	$FeAs_2$
Hematite, iron oxide	Fe_2O_3
Taenite, iron and nickel	Fe, Ni
Chalcopyrite, iron-copper sulphide	$FeCuS_2$
Tetrahedrite, iron-copper-antimony sulphide	$Fe_2Cu_{10}Sb_4S_{13}$
Linneite, cobalt sulphide	Co_3S_4
Glaucodotite, cobalt arseno-sulphide	$CoAsS$
Polydymite, nickel sulphide	Ni_3S_4
Rammelsbergite, nickel arsenide	$NiAs_2$
Chalcocite, copper sulphide	Cu_2S
Berzelianite, copper selenide	Cu_2Se
Famatinite, copper antimono-sulphide	Cu_3SbS_4
Stromeyerite, copper-silver sulphide	$CuAgS$
Aguilarite, silver seleno-sulphide	$Ag_2 (S, Se)$
Naumannite, silver selenide	Ag_2Se
Hessite, silver telluride	Ag_2Te
Sylvanite, silver-gold telluride	$AgAuTe_4$
Calaverite, gold telluride	$AuTe_2$
Natural zincite (impure), zinc oxide with manganese	$(Zn, Mn) O$
Tiemannite, mercury selenide	$HgSe$
Coloradoite, mercury telluride	$HgTe$
Clausthalite, lead selenide	$PbSe$
Chiviatite, lead-bismuth sulphide	$PbBi_4S_7$
Beegerite, another lead-bismuth sulphide	$Pb_6Bi_2S_9$
Guitermanite, lead-arsenic sulphide	$Pb_3As_2S_6$
Guanajuatite, bismuth seleno-sulphide	Bi_2Se_2S

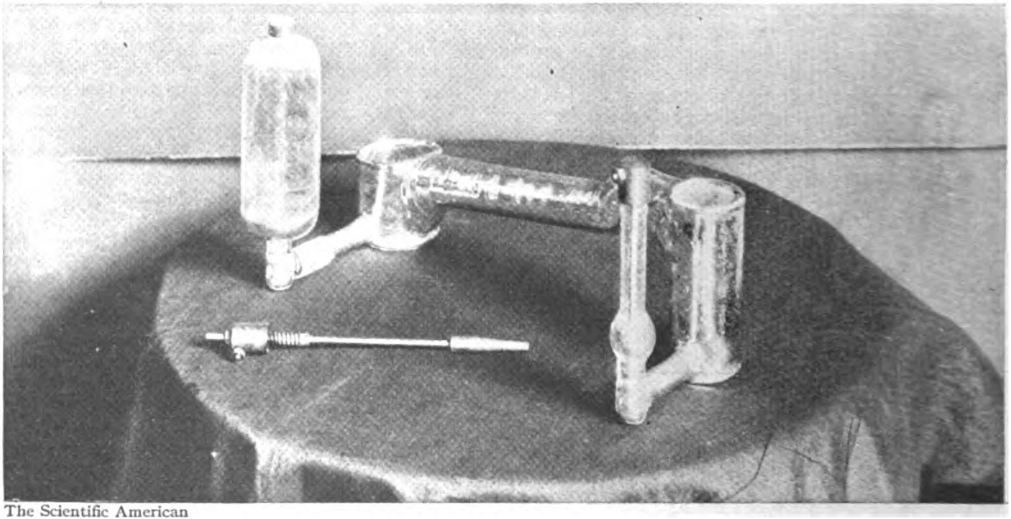
POOR DETECTORS

Anthracite (hard coal), carbon with impurities	C
Artificial metallic titanium	Ti
Ilmenite, iron-titanium oxide	$FeTiO_3$
Psilomelane, hydrated manganese oxide	$MnO \cdot OH$
Metallic iron (artificial)	Fe
Arsenopyrite, iron arseno-sulphide	$FeAsS$
Magnetite, magnetic iron oxide	Fe_3O_4
Pentlandite, iron-nickel sulphide	$(Fe, Ni) S$
Bornite, iron-copper sulphide	$FeCu_3S_4$
Stannite, iron-copper-tin sulphide	$FeCu_2SnS_4$
Smaltite (Safflorite), cobalt arsenide	$CoAs_2$
Cobaltite, cobalt arseno-sulphide	$CoAsS$
Metallic nickel (artificial)	Ni
Ullmannite, nickel antimono-sulphide	$NiSbS$
Domeykite, copper arsenide	Cu_3As
Covellite, copper sulphide	CuS
Rickardite, copper telluride	Cu_4Te_3
Eucairite, copper-silver sellenide	$CuAgSe$
Aikinite, copper-lead-bismuth sulphide	$CuPbBiS_3$
Argentite, silver sulphide	Ag_2S
Empressite, silver telluride	$AgTe$
Argyrodite, silver-germanium sulphide	Ag_8GeS_6
Petzite, silver-gold telluride	Ag_3AuTe_2
Alaskaite, silver-lead-bismuth sulphide	$Ag_2PbBi_4S_8$
Nagyagite, gold-lead antimono-telluro-sulphide	$AuPb_6 (Sb, Te)_4S_9$
Metacinnabarite, mercury sulphide	HgS
Onofrite, mercury seleno-sulphide	$Hg (S, Se)$
Altaite, lead telluride	$PbTe$
Bismutoplagionite, lead-bismuth sulphide	$Pb_5Bi_8S_{17}$
Galenobismutite, lead-bismuth sulphide	$PbBi_2S_4$
Lilianite, lead-bismuth sulphide	$Pb_3Bi_2S_6$
Arsenic	As
Antimony	Sb
Bismuth	Bi
Tetradymite, bismuth telluro-sulphide	Bi_2Te_2S
Tellurium	Te

NON-DETECTORS

(Although they might be expected to be detectors)

Rutile, titanium oxide	TiO_2
Zircon, zirconium-silicon oxide	$ZrSiO_4$
Columbite, iron-columbium oxide	$FeCb_2O_6$
Tantalite, iron-tantalum oxide	$FeTa_2O_6$
Chromite, iron-chromium oxide ("chrome iron ore")	$FeCr_2O_4$
Ferberite, iron-tungsten oxide	$FeWO_4$
Uraninite (impure), uranium oxide	UO_2
Alabandite, manganese sulphide	MnS
Troilite, iron sulphide	FeS
Franklinite, iron-zinc oxide	Fe_2ZnO_4
Millerite, nickel sulphide	NiS
Cuprite, copper oxide	Cu_2O
Marmatite, iron-zinc sulphide	$(Fe, Zn) S$
Greenockite, cadmium sulphide	CdS
Cinnabarite, mercury sulphide	HgS
Cassiterite, tin oxide	SnO_2
Stibnite, antimony sulphide	Sb_2S_3
Bismuthinite, bismuth sulphide	Bi_2S_3
Selenium (crystallized)	Se



The Scientific American

PROFESSOR MIETHE'S GOLD-MAKING LAMP

This lamp, built of fused quartz and containing mercury vapor, is an exact replica of the lamp used by Professor Miethe in the experiments which were reported to have yielded gold from mercury. American investigators, repeating these experiments, have failed to confirm them. German reports also indicate doubt of Professor Miethe's results.

Courtesy of Dr. O. von Miller, Deutsches Museum, Munich

WHERE A REAL ALCHEMIST WORKED

In the famous German Museum, at Munich, Germany, there has been constructed this exact model of a laboratory used by the ancient alchemists in their chemical researches, one of the chief of which was the attempt to make gold out of baser metals. The curiously-shaped pieces of alchemical apparatus were the parents of many devices used in modern laboratories.

The New Alchemy Fails to Make Gold

Over a year ago Professor Adolphe Miethe, a well-known chemist of Berlin, startled the scientific world by the announcement that he had succeeded in the century-long quest of the ancient alchemists. He had accomplished, he believed, the transmutation of a base metal—in this case mercury—into gold. The process was quite simple. Some mercury was put into a quartz tube and boiled. Through the mercury vapor thus produced a strong electric current was passed, exactly as it is passed in the familiar Cooper-Hewitt lamps and in other forms of mercury vapor arc. After some hours of the action of the current the mercury was found, Professor Miethe reported, to contain a minute amount of gold which had not been there before.

He assumed that a few of the atoms of mercury in the arc had been transmuted by electric forces into atoms of gold. A little later, a Japanese scientist, Dr. H. Nagaoka, of Tokyo, announced the probable transmutation of mercury into gold by a somewhat different method; the effective agent in this instance being bombardment of the mercury surface by a stream of high-speed electrons.[*]

Immediately following the first announcement by Professor Miethe, the *Scientific American* arranged for the repetition and critical examination of the experiments, the work being conducted by Mr. Roger S. Estey, working under the direction of Professor H. H. Sheldon in the physical laboratories of Washington Square College of New York University, New York City. The result of this test is now reported.[†]

The tests were entirely negative. Experiments with special apparatus, devised to test the theory of atomic transmutation supposed to underly Professor Miethe's results, showed no transmutation. Other tests conducted with the exact method and apparatus used by Professor Miethe himself, led to the same result. Although the *Scientific American* is properly cautious in claiming that Professor Miethe's results are definitely erroneous, the fact is clearly evident that these results have failed to be confirmed after a most careful and competent test.

Meanwhile a committee of German chemists has been scrutinizing Professor Miethe's results and materials in his own laboratory. These experts, too, are critical. It is reported that the method used by Professor Miethe to purify his mercury before use was incapable of removing the last traces of gold which might have been present as an impurity. It is probable, says the German committee,§ that the gold which was found *after* exposure of the mercury to the electric forces had really been there all the time. The implication is that Professor Miethe neglected to purify his materials and that his work is entirely wrong. So far as now announced, no repetition of Professor Nagaoka's experiments has yet been undertaken, but the negative result in Professor Miethe's case will naturally cast some suspicion on the Japanese claims as well.

---

[*] Professor Nagaoka reports his results in *Nature* (London), vol. 116, pages 95-96 (July 18, 1925).

[†] "Tests Fail to Confirm Transmutation to Gold," *The Scientific American* (New York), vol. 133, pages 296-297 (November, 1925).

Transmutation stands, therefore, in just the situation in which it stood before the recent excitement. Atomic theory indicates that it is possible. The atom of mercury has only one more planetary electron than has the atom of gold. The atom of another element, thallium, has two more; the atom of lead three more; the atom of bismuth four more. On the other side, platinum has one less planetary electron than gold; our familiar tungsten has five less electrons. Any of these atoms might be converted, by simple enough changes, into gold atoms. Probably some of them will be so converted before long. But there is no evidence, as yet, that any of them actually has been converted. Cheap gold—so cheap, for example, that we could use gold wire for antennas and gold plates for condensers—would have many industrial and scientific utilities, but it is not now in sight.

Compound Interest in Ether Waves

Readers of this Department are familiar with the many puzzling facts recently discovered about the radiation of light or of other ether waves by atoms; puzzles related to the so-called quantum theory of radiation.* Radiation seems to come out of atoms, you remember, in tiny separate pulses—in what Sir Oliver Lodge called so vividly "squirts" of energy. All rays, light and radio included, seem to consist of these small separate bundles or particles. On the other hand, there are facts which indicate that radiation consists of waves. How to reconcile these two conflicting ideas is probably the most pressing problem of modern physics.

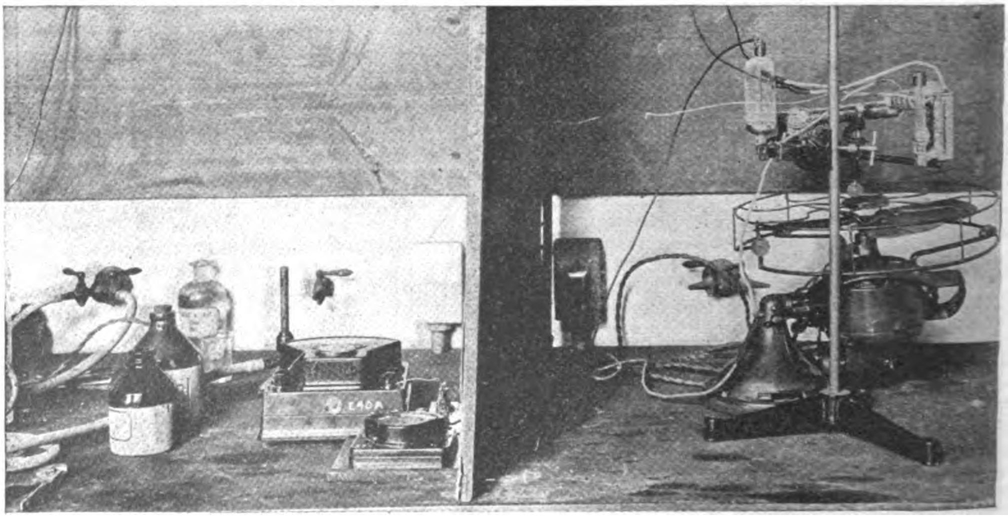
Many physicists have suspected that this emission of radiation in tiny squirts might be accompanied by a less jerky process of some sort occurring inside the atoms, a process of which we are not yet aware. For example, energy might accumulate, somehow, in each atom until it reached the bursting point. Then some of it would escape as radiation. This would be not unlike the operation of the great geysers of Yellowstone Park or of New Zealand. In these curious volcanic springs steam accumulates deep in the earth until its pressure is too great. Then it suddenly blows up. A vast column of water is hurled high into the air. This relieves the pressure. The water falls back. Steam begins to accumulate again and the cycle is repeated. Possibly atomic radiation is something of this same sort.

There has recently been added to these sug-

---

§The report, by E. H. Riesenfeld, Wilhelm Haase, Erich Tiede, Arthur Schleede and Frieda Goldschmidt, is abstracted, in English, in a newspaper dispatch by Science Service, Washington, D. C., published in *Science* (Lancaster, Pa.), vol. 62, number 1601, page xiv (September 4, 1925).

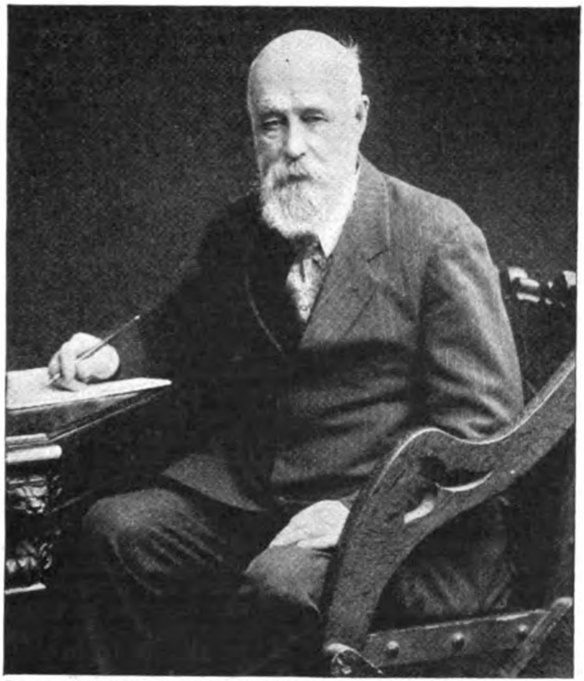
*See, for example, "New Theories of Ether Waves," Popular Radio for August, 1925, pages 168-171.



The Scientific American

HOW THE MODERN GOLD-MAKING CLAIMS WERE TESTED

The replica of Professor Miethe's lamp, as set up in New York by Professor Sheldon and Mr. Estey, is at the right of the photograph. Underneath it is an electric fan used to keep it cool enough that the quartz will not melt. In operation, the lamp is surrounded by a wooden box, one side of which is shown in place. This prevents escape of the dangerous ultra-violet light rays which the lamp gives off while operating.



From a photograph made for Popular Radio by Gilman and Co., Oxford

DISTINGUISHED MATHEMATICIAN POINTS OUT RADIATION LAW

Dr. Alfred Lodge, of Oxford, England, calls attention to the fact that the emission of pulses of radiant energy from atoms occur as though the atom accumulated energy from somewhere in accordance with the familiar law of compound interest, a pulse of energy being given off whenever the accumulated atomic "interest" reaches a sufficiently high value.

gestions the interesting observation that if energy does thus accumulate inside an atom between bursts of radiation, its accumulation appears to follow the familiar law of compound interest, the law according to which the sum increases at a rate proportional to itself. This suggestion comes from Dr. Alfred Lodge, brother of Sir Oliver Lodge and an investigator of distinction in the field of pure mathematics.†

"Interest is compound until it is paid, and then begins again." The energy of the atom grows until there occurs a "payment" of radiation; then it is left to grow again until it is time for another dividend. "Within the atom the energy grows continuously, but it is given out spasmodically." The energy which thus accumulates within the atom is presumably "internal electronic energy, the only kind of disturbance which can affect the ether and either radiate or absorb. It is doubtless associated with some particular frequency of revolution or internal vibration. Mere molecular or mechanical energy alone would not radiate. Matter alone has no link with the ether."§

Better knowledge of what ether radiation really is, is one of the great needs of radio theory. We talk glibly of "waves" and "vibrations" and what-not, but it is worth while to remember occasionally that these are merely words. In plain truth we do not know in the least what constitutes a ray of light or a beam of heat waves or the spreading radio waves which carry our signals around the earth. All these things are mysteries which science has still to solve.

There is undeniably something satisfying in the idea that the universe may be full of energy which we do not perceive, that this energy is accumulated, like compound interest, by the structure of an atom and is paid out, when it grows great enough, in the form of ether waves. This, one gathers, is not far from the idea held by Sir Oliver Lodge. Dr. Alfred Lodge, as becomes a mathematician, is cautious of speculation. He confines himself to pointing out the interesting fact that the mathematical formulation of the quantum theory of ether radiation and the mathematical formulation of compound interest are the same.

---

†The suggestion of Dr. Alfred Lodge is quoted by Sir Oliver Lodge in a letter in *Nature* (London), vol. 115, page 798 (May 23, 1925). Further details are given by Dr. Alfred Lodge himself in letters in the same periodical, page 838 (May 30, 1925) and page 947 (June 20, 1925).

§The quotations are from the letter of Sir Oliver Lodge cited.

Radio During the Next Eclipse

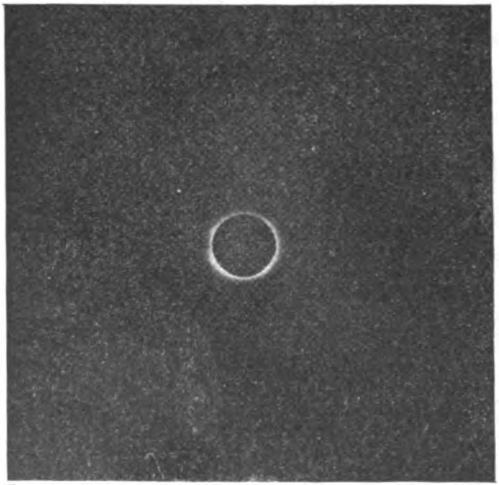
THE total eclipse of the sun, which occurred last January over the northeastern states, was one of the great events of radio as well as of astronomy. By the co-operation of thousands of radio engineers and broadcast listeners, as well as of the broadcasting stations, data were obtained which meant a great deal for our knowledge of the propagation of radio waves over the earth's surface. There will be another total eclipse of the sun next January, but it will be much less of a radio event and scarcely anything of a public spectacle.

This is because of a difference of location. Next year's eclipse will be visible (as a total eclipse) only in eastern Africa, the Indian Ocean and the islands of Sumatra, Borneo and Mindanao. It occurs on January 14, 1926, beginning at sunrise in the African mountains north of Lake Victoria and ending at sunset in the ocean southeast of the Philippine Islands. Totality will last from a fraction of a minute up to four minutes and ten seconds, about twice as long as the maximum totality during last year's eclipse in the United States.

Astronomic expeditions will be stationed at several points on the Island of Sumatra, which island the eclipse crosses during the mid-portion of the afternoon. It is possible that expeditions will be stationed, also, on the east coast of Africa and in Mindanao. The radio stations in Sumatra, Borneo and elsewhere near the path of totality will probably make observations. Scientists in Europe are planning other tests with around-the-world radio, in order to see whether the eclipse will have important effects on radio transmission over parts of the earth not close to the shadow. There is no probability, however, that the radio investigations will be organized with anything like the completeness and care exhibited last year. There are so few possible observers in the region of the eclipse that such effort would be wasted.

Any radio listener, on ship or ashore, who happens to be in or near the zone of totality on January 14, should be sure, however, to make what observations he can. The editor of this department will be glad to supply detailed suggestions for any specified locality on request. In the absence of advance plans, what the listener should do is to tune in some large transmitting station on the opposite side of the path of totality and listen to this station for about one hour before totality, through totality and for about one hour afterward, recording the exact second of any marked changes of intensity. POPULAR RADIO will be glad to receive reports of such observations. Exact times, preferably in Greenwich time, are essential; as is also an exact specification of the location, by latitude and longitude.

Persons not equipped with radio receivers, but who expect to be within or near the eclipse path, can make some useful observations also. If you plan to be in that part of the world on January 14, write this department and say so. We shall be glad to supply detailed data of the eclipse path, the time of totality, suggested observations and the like. Be sure to give us the exact location of the place where you expect to be.



Courtesy of Professor Edward S. King

THE SUN'S CORONA PHOTOGRAPHED BY INVISIBLE LIGHT

During the eclipse of the sun last January, Professor Edward S. King, of Harvard University, made this remarkable photograph at the Maria Mitchell Memorial Observatory, on Nantucket Island. The photograph was made by ultraviolet light, passing through a quartz lens covered with a film of silver, so that it was quite opaque to ordinary light.

A Photo-electric Grid-leak

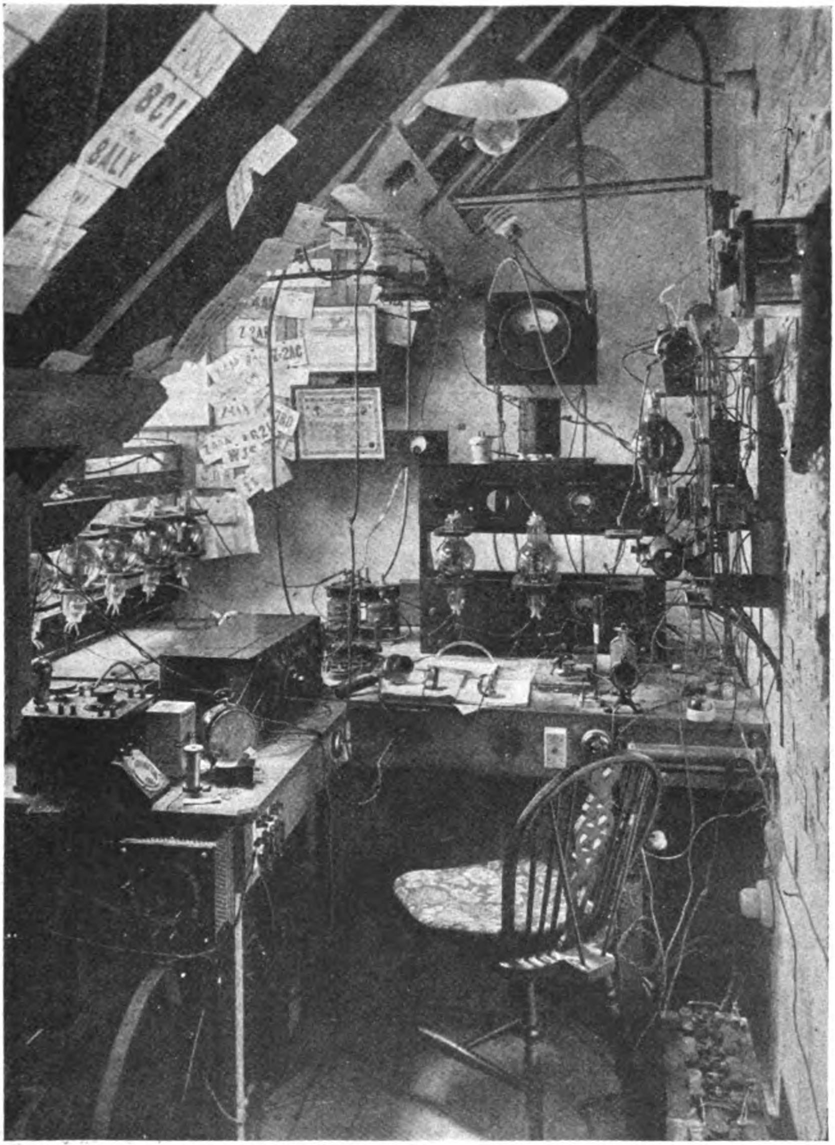
THE problem of obtaining a variable high resistance for grid-leak purposes has been solved in a novel manner by a British experimenter, Mr. G. G. Blake. He uses a selenium cell.*

The metal selenium has the peculiar property, you remember, of altering its electric conductivity when light falls on it. This property is put to use in making the selenium photo-electric cells used in many kinds of apparatus in which light signals are converted into electric signals. It was a selenium cell, for example, which was used in the famous "electric dog" of Mr. John Hays Hammond, Jr., a small device mounted on wheels and which would follow a light from place to place, just as a dog follows a man.

Normally, selenium has a rather high electric resistance. When light falls on it this resistance decreases. The amount of the decrease depends on the intensity of the light. Mr. Blake mounts a selenium cell, therefore, in place of the grid-leak. This cell can be illuminated by a light ray, the intensity of which can be increased or decreased by means of a shutter or in any other convenient way. Adjustment of the light increases or decreases the resistance until the proper value is attained.

---

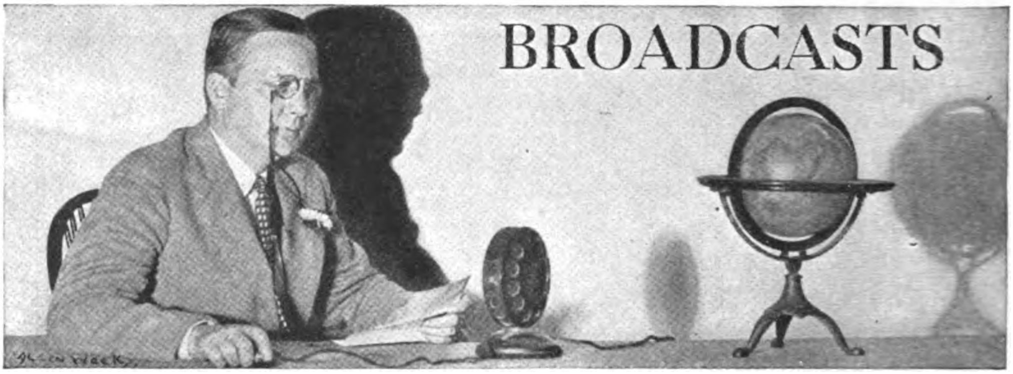
*"A Grid-leak Controlled by Light," by G. G. Blake. *The Wireless World* (London), vol. 17, page 254 (August 26, 1925).



From a photograph made for POPULAR RADIO

An Amateur Station (2NM) that is Heard Around the World

A SHORT time ago the newspapers reported that Mr. Gerald Marcuse, a radio amateur in Surrey, England, talked by radio with the operator of the *U.S.S. Seattle*, 600 miles east of Australia. In response to a request from POPULAR RADIO, Mr. Marcuse reports: "I am sending you a picture of my gear which has been successful in sending telephony and music all over the world and in some cases in the remotest part of the world. Regular schedules are maintained with Mosul twice a week. My speech has also been successfully received in the following countries: U. S. A., Canada, Mexico (IK), Australia, New Zealand, India, Egypt, Iraq, Argentine (A8) and although I have received reports from South Africa of my CW QSA have not yet received any reports of my speech being received there. For the guidance of your readers I give you my regular times of transmission; every morning at 0600, Friday 2300, Sunday 1400 C.M.T."



Conducted by J. Andrew White

In this department the Dean of Broadcasters—whose voice is known to millions of broadcast listeners—records items of interest and value to all radio fans everywhere.

"Radioville" Is in Alaska

In Alaska there is a town called Radioville. Neither the atlas nor railroad and post office records confirm this, but Joseph P. Bauer signed his name to a telegram bearing this address which was received at KOA, the Rocky Mountain broadcasting station, and it is a fair assumption that the sender of the message knows where he lives.

* * *

Ireland Joins the Ethereal Chorus

Word from Ireland carries the encouraging information that the plan for establishing broadcasting stations as a State concern has been approved by the Minister of Finance, and work will soon be begun on initial installations at Dublin and Cork.

* * *

Why 90 Percent of the World's Broadcasting Is Done in the United States

There has been some talk about the United States Government establishing a Commission on Communications, and the idea is not popularly received in quarters where the freedom from State restriction is known to have made possible America's amazing development of broadcasting. At the radio industries banquet Senator C. C. Dill of Washington sounded a warning that was heard by listeners to the chain of twelve stations hooked up for that occasion, an audience of probably 5,000,000 persons, who were told by the Senator: "The day you give to any board in Washington the power to regulate radio, that day will the liberty of radio and the radio industry end. In some other countries they have a radio censorship and the result is that 90 percent of all broadcasting is done in our own country."

The Ghost-seekers Adopt Radio

Spiritists in convention at Paris made the strange admission that mediums are recognized as being generally unsatisfactory and untrustworthy, and it seems likely that they will abandon the long standing and seemingly only plausible means yet devised for communicating with the dead and substitute therefor some new adaptation of the radio. Certainly this is a naïve supposition, resting probably on the sweetly simple belief that there is something mysterious about the transmission and reception of radio messages that fits in with mediumistic phenomena, whereas radio is merely a utilization of scientific electrical laws fixed and inflexible and so simple that any person can grasp the subject with little study and an absolute novice manipulate a set and get results without the slightest surprise at the successful accomplishment at the first trial. But the spiritists declared that a new means for reaching those in the other world "must" be devised—so, radio.

* * *

A Belgian Amateur Makes a Record

A Belgian amateur has accomplished the trick of communication half-way around the world to New Zealand, and that's a new and distinctive achievement to be written down in the records of the Radio Club Belge, for it was the vice-president of that organization, A. Courtois, who put over the distance test from his station 4YZ, at Verviers. Using sixty-four watts on a forty-five-meter wavelength, he communicated for several minutes with Ivan O'Meara of Gisbourne, New Zealand, who answered and was heard, although the transmission was effected in broad daylight at his end. English stations have reached New Zealand before, but this is the first time for Belgium.

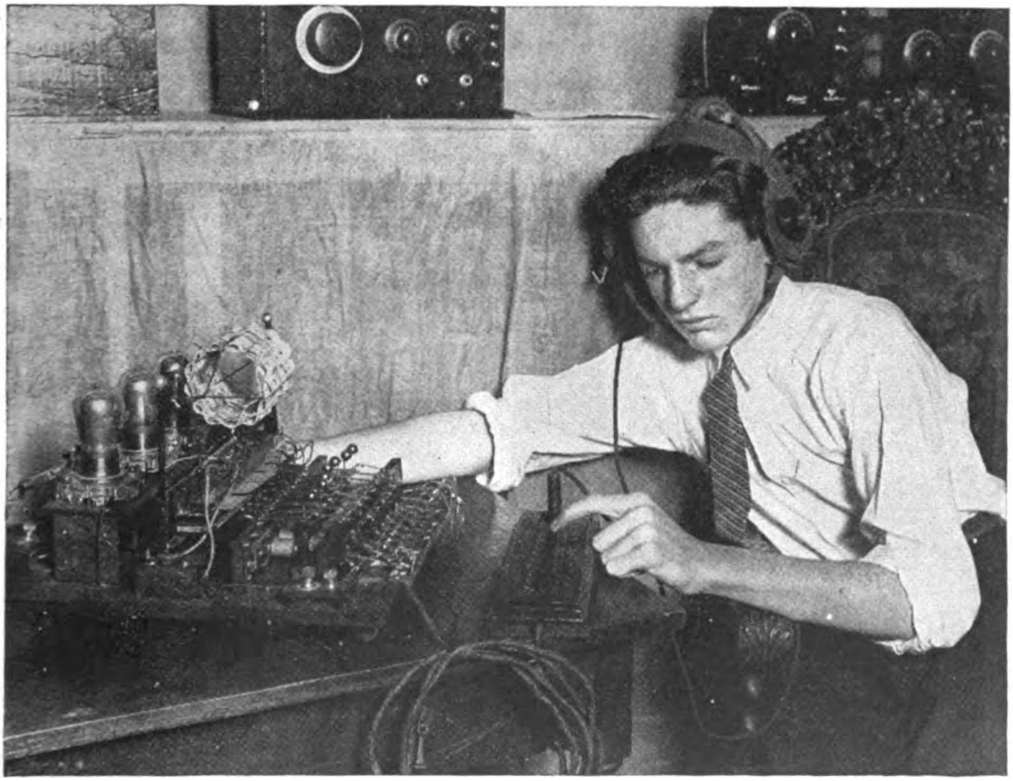
A Novel Radio Pilot for Flyers

AIRPLANE pilots will no longer be required to listen in continuously for the code signals which keep them on their course through darkness and fog if their craft is equipped with the newest type of receiver developed at McCook Field. When the receiver is properly tuned to the radio beacon it operates three tiny electric lights mounted on the dashboard, indicating whether the airman is on his proper course or veering to the left or right. The central light is white, and when lit it means that the proper course is being held to; a red light flashes on if the craft is off to the left and a green lamp on the right tells if the veering is in that direction. This is accomplished by an interlocking signal system which is simplicity itself. The transmitter at the flying field which sends out the radio beacon to guide the aviator transmits two distinct signals. If the flier is off the course to the left only one signal is received, the Morse letter A (dot, dash); if off to the right, the letter N (dash, dot); if fiying exactly on the prescribed course these two signals combine for a series of dashes. It is these code impulses picked up by the radio receiver which light the various lamps, through a relay. The unbroken series of dashes operates the white light, and since this means that both A and N signals are being received with equal intensity and have therefore combined, this is the proper course. Deviating to the left of the course brings in the letter A, which lights the red light; if off to the right, N alone comes through and the green lamp glows, so visual evidence of whether or not the aviator is holding to his course is always before him.

* * *

Less Interference from Ship Radio

SHIPS flying the American, British, Irish or Canadian flags are now required to keep off the broadcasting waves when within two hundred and fifty miles of the shores of these countries. The new order is, of course, designed to prevent needless interference between broadcast programs and ship messages, a workable and useful arrangement for both interests. The distress call wavelength, six hundred meters, is to



Kadel & Herbert

A RADIO SET WHICH TUNES ITSELF

One of the novel radio receivers entered in the contest for amateur set builders at the recent Radio World's Fair was made by John J. Muller in the shape of a typewriter. To tune a station on this set you merely press a button which actuates electric magnets, which in turn cut in portions of the tuning coil.

be used, and the channels above reserved to ship communication. The Great Lakes, too, are included in the agreement. Safety of life at sea has always been a matter of first consideration since the advent of radio, and vessels have in consequence been favored with the best channels of communication, but broadcasting has so markedly increased in importance that the old order is changing daily, and perhaps the most significant step yet taken is this one, prohibiting ships the use of the three hundred and four hundred and fifty meter waves when they are sufficiently close to shore to spoil the enjoyment of the broadcast fans.

* * *

Listening In on Japan

THE Japanese high power system has gone over to private hands finally, a transfer that has been the subject of long discussion. Four fifty-kilowatt stations are planned, the material and equipment to be purchased from an American company. New stations are to be built at Isamimura and Kaizomura, the latter to communicate with the United States. The system for overseas message traffic will include the present stations at Harunomachi and Tomioka communicating with Germany, France and the Far East. Tomioka now handles messages for Europe *via* Hawaii and San Francisco, thence to the cross-Atlantic chain. Meanwhile, broadcasting has not been overlooked in Japan, the programs having started last July from Nagoya and since then Tokyo and Osaka have joined in.

Pacific & Atlantic

A HERO OF THE S-51 DISASTER

Over one hundred hours on the job, with never more than three hours sleep in each twenty-four was the record of James S. Herren, radio operator at the submarine base at New London, Conn., when the accidental sinking of submarine S-51 necessitated constant vigilance there.

Re-broadcasting Yankee Programs in Germany

THE Germans are so much interested in receiving American broadcast programs that an agreement has been reached to provide special equipment for this purpose and attempt to re-broadcast features transmitted by the Radio Corporation's super-power station, using for the purpose the central station of Konigswusterhausen. And if this is successful it is proposed to increase the power of one of the German transmitters and at regular intervals send out an "American Program" for listeners in the States, to be re-broadcast, of course, by an RCA plant here. None other than Dr. Hans Bredow, State Secretary of the Reichspost, is authority for this statement, which opens up the interesting possibility that performances from the opera houses at Berlin, Munich and Frankfurt-Main may be transmitted overseas as they are now being heard throughout the German provinces.

* * *

A New Station to Compete for Long-distance Honors

THE Daventry station, England's new high power broadcaster located in Northamptonshire, should come across the ocean with good volume, for twenty-five kilowatts of power is being used on a wavelength of 1,600 meters. Chelmsford is now through and the famous call 5XX has been transferred to the latest candidate for distance honors erected by the British Broadcasting Company. There will be re-broadcasting from Daventry, so if you pick up this station on a low wavelength, before you begin bragging about receiving England direct, don't overlook the fact that its wave is the 1,600 one, above the span of the average receiver used in the United States.

* * *

The Difference Between "High-power" and "Super-power" Stations

MISUSE of the designation "super-power" as a descriptive term for many of the broadcasters using high-power is not to the liking of officials of the Department of Commerce. Fifty kilowatts or more are required to climb into that classification, and there are only three stations proposed to operate with that electrical wallop. Fifty-two stations in the B classification are using power above a half kilowatt. KDKA is licensed to use ten kilowatts experimentally, and half that power is permitted to ten other broadcasters. Two are permitted use of 3,500 watts, two others 3,000, and an additional two employ 2,500 watts. Next in line are three stations with 1,500 watts, twenty-five which use 1,000, or one kilowatt, and there are seven broadcasting with 750 watts. But, says the Department of Commerce, these are high-power stations, not super-power.

A YOUTHFUL AMATEUR MAKES A RECORD ON A UNIQUE HOME-MADE SET

Arthur Collins, a fifteen-year old amateur of Cedar Rapids, Iowa, has the distinction of being the first to pick up the low-wave signals from station WNP, aboard the McMillan ship BOWDOIN *in the Arctic. Collins' home-made equipment includes pieces of coal and coke used as rectifiers, a coil taken from a Ford car and glass towel racks for insulators.*

A Convict Radio Student

CONVICT No. 13,377 is the most popular of the more than 500 men imprisoned at a Pennsylvania penitentiary, for he recently completed a five-tube radio receiving set and each night he entertains scores of his fellow-unfortunates with programs of the DX variety. It all started when No. 13,377 enrolled in a radio course that is conducted by a Pennsylvania college.

* * *

"Radio Insanity"

THE establishment of a regular service of radio concerts and entertainments by the Post Office Department of Vienna has resulted in what is called the first case of radio insanity on record in Austria. A forty-six-year-old lithographer complained to the police that the whole world was talking about him. He said he was connected with a radio receiver and could distinctly hear people in every part of the globe gossiping about him. He asked, pitifully, to be disconnected from the radio waves. He has been placed under observation in an insane asylum.

* * *

Licenses for Receiving Sets

ON January 1st Sweden put into effect new radio regulations and new licenses were required. Licenses for private receiving sets cost twelve kronen, but when loudspeakers are employed in public places or for advertising, special permits at increased fees are necessary. The regulations require that regular receiving sets must not be connected with automatic recording apparatus, and also that listeners must maintain secrecy as to all communications heard, except, of course, the broadcast programs. The copying of news items broadcast by a publisher is prohibited for commercial purposes. All licenses issued carry a provision that the sets covered may be inspected at any time by the authorities.

* * *

Broadcasting Hours for the Blind

DR. GUSTAV GAERTNER, a German professor, has conceived the idea that the early hours of the morning might be devoted exclusively to radio broadcasting for the blind. A single speaker could thus reach the blind and those with defective vision. He suggests finding out what such persons would like to hear through a "round-robin" addressed to the blind themselves; he himself suggests a program of important political and current events, that would be followed by an hour of reading from good literature, both fiction and more serious works, and an hour of simple scientific information.

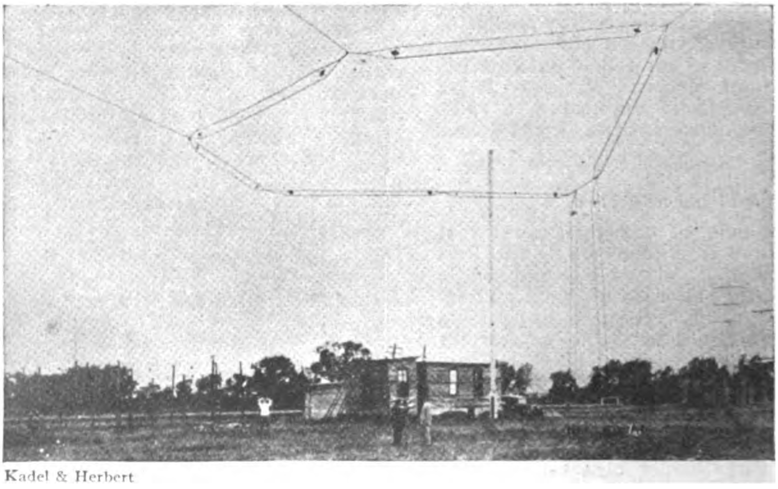
Stations That Broadcast Weather Forecasts for the States

Alabama	WSY, WEAP, WSB, WMC, NAA.
Arizona	KFAD, KOA, KOB.
Arkansas	KTHS, WDAF, WHB, KSD, WMC, WBAP.
California	KGO, KLX, KFI, KHJ, KMJ.
Colorado	KOA, KLZ.
Connecticut	WABL, WNAC, WGI, WGY, WHN, WJAR, WEAN, NAA, WAHG, WEAF, WJZ.
Delaware	WRC, WCBM, WCAO, WIP, NAA.
Florida	WDAE, NAA.
Georgia	WSB, NAA.
Hawaii	KGU.
Idaho	KGO, KFAU.
Illinois	WAAF, WGN, WLS, KYW, WHAS, WJAN, WOC, KSD, WEW.
Indiana	WAAF, WGN, WLS, KYW, WHAS, KDKA, WGBF, WBAA.
Iowa	WAAF, WGN, WLS, WOC, WOI, WHO, KFNF, WEAU, WCCO, WHB, KSD, WEW, WJAG, WIAK, WOAW.
Kansas	WGN, KFNF, KSAC, WEAH, WDAF, WHB, KSD, WOAW.
Kentucky	WHAS, KSD, KDKA, WMC, NAA.
Louisiana	KTHS, KSD, WBAP, WEAY.
Maine	WNAC, WGI, WGY, WHN, NAA, WEAF, WJZ, WAHG.
Maryland	WRC, WCBM, WCAO, WIP, KDKA, NAA.
Massachusetts	WNAC, WGI, WGY, WHN, WJAR, WEAN, NAA, WEAF, WJZ, WAHG.
Michigan	WAAF, WGN, WLS, KYW, WWJ, WCX, WWAO, WKAR, WREO, WABM, KDKA, WBAA, WEBK, WBDC.
Minnesota	WAAF, WCCO, WGN, WLS, WOI, WEAU, WPAU, WOAW, WPAK, WDAY.
Mississippi	WEAP, WMC, NAA.
Missouri	WGN, WLS, KFNF, WOS, WDAF, WHB, KSD, WEW, WOAW.
Montana	WGN, WCCO, KFBB.
Nebraska	WGN, WOI, KFNF, WEAU, WDAF, WHB, KSD, WCAJ, WFAV, WJAG, WIAK, WOAW.
Nevada	KGO.
New Hampshire	WNAC, WGI, WGY, NAA, WEAF, WJZ, WAHG.
New Jersey	WOAX, WHN, WJZ, WIP, WOO, NAA.
New Mexico	KOA, KLZ, KOB.
New York	WGY, WGR, WCAD, WMAK, WHN, WJZ, WHAM, WEAF, WAHG, WNYC, NAA, KDKA.
North Carolina	WRC, WBT, WFBQ, KDKA, WTAR, NAA.
North Dakota	WAAF, WGN, WCCO, WPAU, WPAK, WDAY, KDLR.
Ohio	WLW, WEAR, WBAV, WEAO, KDKA, NAA.
Oklahoma	KTHS, WEAH, WDAF, WHB, KSD, WNAD, WBAP.
Oregon	KGO, KFEC, KGW.
Pennsylvania	WRC, KDKA, WCAO, WHN, WDBC, WIP, WOO, WQAN, WFBG, WEAF, NAA, WAHG.
Porto Rico	WKAQ.
Rhode Island	WNAC, WGI, WGY, WHN, WJAR, WEAN, WEAF, WJZ, WAHG, NAA.
South Carolina	WSB, NAA.
South Dakota	WAAF, WGN, WOI, WEAU, WCCO, WJAG, WOAW, WCAT, WNAX.
Tennessee	WHAS, KSD, WMC, NAA.
Texas	WCM, KFLX, WOAI, KFGX, WRR, WFAA, WBAP, WEAY.
Utah	KOA, KLZ, KDYL.
Vermont	WNAC, WGI, WGY, WHN, WEAF, WJZ, WAHG, NAA.
Virginia	WRC, WTAR, NAA.
Washington	KGO, KFEC, KGW, KFQX, KFOA, KJR.
West Virginia	KDKA, WRC, NAA.
Wisconsin	WAAF, WGN, WLS, KYW, WOI, WCCO, KFIZ, WABN, WHA, WCAY, WHAD, WLBL, WTAQ.
Wyoming	KOA, WCCO, KLZ, WGN.

* * *

Schoolboys Make Own Receiver Cabinets

THOUSANDS of radio cabinets are being shipped from Latvia to this country. These cabinets are shipped unfinished in knock-down form and most of them are made by schoolboys in Riga.



Kadel & Herbert

THE NEW HORIZONTAL WAVE ANTENNA

This is the experimental antenna made up of a number of separately tuned sections for transmitting a horizontally polarized wave. This is the field laboratory of E. F. W. Alexanderson of The General Electric Company who is investigating the scientific aspects of this development as they apply to the future of broadcasting.

Pacific & Atlantic

A CONSTELLATION OF STARS SIGN CONTRACTS FOR RADIO CONCERTS

Twenty-five of the great operatic stars are included among the artists who recently contracted to perform before the microphone. Here Anna Case is signing up while Louise Homer, Reinald Werrenrath, Toscha Seidel and Hilda Lashenska wait their turns. Mr. Atwater Kent is presiding at the ceremony.

The BROADCAST LISTENER

Comments on radio programs, methods and technique —from the point of view of the average fan

By RAYMOND FRANCIS YATES

Baby Peggyizing the Ether

It really requires a lot of nerve to write what we are going to write with all of the mothers and fathers that we have in this country. If you were as old as we are you would know that a mother or a father is a pretty weak thing when it comes to discovering "cuteness" in any of the human species under six years and three months. Just let anybody's baby gurgle at a mother, and she melts like a Bayberry candle. Fathers fall a little harder, but they are essentially weak when it comes to "little hands" and "li'l' fat legs." Our movie directors know their business when they work in the cradle with the pretty baby. "Aw, isn't it sweet," has held the record for movie soliloquizing since the first nickelodeon was installed in the opera house out in Oskosh back in 1907.

They can "Baby Peggy" the movies until the cows come home, but when the babypeggyization of the radio begins, we grab our walking stick and hobble right out to the voting booth to put in one big, fat vote against the practice. That shows what kind of a radio listener we are. Once in a great while (oh, say every seven years), we might have the patience to listen to somebody's three-year-old recite Mother Goose. When you hear a little tot recite a nursery rhyme from a studio, you at least know that there is a very happy mother and a very happy father somewhere in the United States, but the few years that we have left on this earth are a bit too precious to be devoting them to the comforts of mothers and fathers. We like our radio on the hoof. Besides there are too many ambitious parents anxious to start their children off on a stage career through any medium that offers the opportunity, and the average studio is as easily exploited in this connection as the church bazaar.

Queen Titania, somebody's baby out at station KHJ, is making a big hit, if we are to listen to the publicity man. The big editorial mind that directs the *Los Angeles Times* permits the publication of the standard picture showing Queen Titania in a fluffy white ballet dress seated in the center of thousands and thousands of letters from her appreciative fans. When you see a picture like that you will know that there is back of it a scheming and wise mother, ferociously intent on putting her offspring in the movies. Mothers like that are pretty hard to beat and so we might just as well fold up our little tent and move on, but this we shall not do without one parting word. *So is your old man.*

* * *

The Tweedledum and Tweedledee of Jazz

The difference between Ben Bernie (WEAF and several others) and Vincent Lopez, is that Mr. Lopez announces like a voice from a Kelvinator and Mr. Bernie announces like a voice from a heating pad. Mr. Lopez is without doubt one of the most naïve announcers in the business, and that is a pretty nasty thing to say about a gentleman who is otherwise so artistic. It seems that Mr. Lopez has made up an announcing form on the style of an application blank for a chauffeur's license and that he simply inserts the names of the numbers in the proper spaces.

Pacific & Atlantic

THE BUFFALO NICKEL INDIAN BROADCASTS

When Two Guns White Calf, who posed for the head on the Buffalo Nickel, came to St. Paul, radio station WCCO persuaded him to broadcast in his native tongue. The only objection of the Blackfoot chief was that the radio was "no good for the sign language."

We have been in line with Mr. Bernie's customers for several months now, and while we may be dumb to the point of inflammation where syncopation is concerned, and while our opinion may not be worth one little pinch of grandpa's snuff, we hold that Mr. Bernie is one of the greatest artists on the air. He is original with his arrangements, and there is a charm to his orchestra which lies safely beyond our power of description. Mr. Bernie is also a suave announcer and when he takes it in his mind to be funny his humor does not strike you in the face like a dish of stewed tomatoes.

* * *

The Menace of Propaganda on the Air

Some day we shall sit down at our L. C. Smith No. 9 and tattoo a thesis on radio propaganda that will cause quite a stir in this big country of ours. Radio is a bit more troubled with propaganda than most people think, and unless the big guns of this department are turned loose, heaven only knows what will happen to these United States. George Creel saved this country once and we can do it again.

The American Civil Liberties Union is planning to put a station up for propaganda purposes, which means, of course, that such an installation would immediately be followed by a station owned and operated by that big, broad-minded body called the National Securities League. Put a radical outfit on the air and you invite the conservatives. Put the conservatives on the air and you invite the radicals.

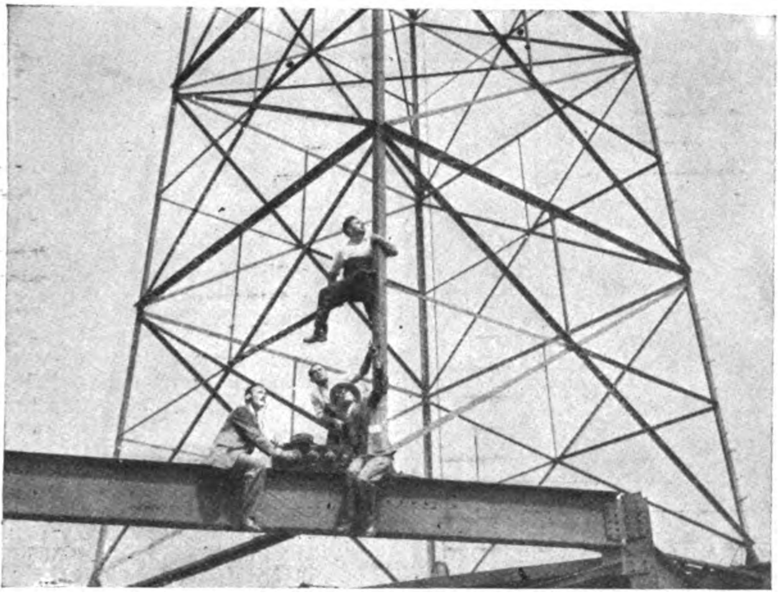
To be real serious, we believe that propaganda over the air is one of the great dangers in broadcasting, and we are opposed to it regardless of the motives displayed. It is bad enough that we have to contend with religious propaganda. Propaganda is a pretty sneaky thing, regardless of its source and how often it pans out that it is pure bunk.

* * *

A Small Improvement in Announcing Methods

It has taken our Johnny-on-the-spot managers four years to discover that the identification of an announcer has no more public significance than the identification of the bus boys at Childs' or the Redcaps at Grand Central. That "this is Norman Brokenshire announcing" or that "this is AON speaking" is inconsequential so long as Mr. Brokenshire or Mr. AON does not attempt to inflict too many witticisms (God, forbid!) and personal opinions upon the wholly helpless audience.

This whole game of broadcasting, it seems to us, has been too largely and too ambitiously devoted to the popularization of bumptious neophytes recruited from the insurance offices, the soda fountains, the ribbon counters, and the boot shops. Broadcasting, except in cases as rare as pearls or charitable Scotchmen, has not been enriched one iota by the administration it receives from the gracious zealots in the studios.



Kadel & Herbert

PICKING UP A PROGRAM FROM A FLYING STUDIO

Popular songs broadcast on a 40-meter wave from a giant Sikorsky plane flying overhead were recently picked up on a receiving set on the roof of station WGBS in New York and rebroadcast. A few days later a small orchestra that included a piano was broadcast from a plane flying over London.

Perhaps we are a little bit touchy on this subject and perhaps we are a little hard and bellicose in our treatment of the matter, but it comes after long deliberation. Time and time again we have stood before the mirror on the bedroom door and asked ourselves, man to man, if we were not a little prejudiced or if perhaps we were not a trifle envious of the Big Names that our studio boys are making for themselves. Time and time again we have done this and time and time again we have turned away feeling pure and justified. From this you can easily imagine that we felt pretty happy over the late tendency of the studio toward the elimination of the wholly unimportant references to the whozis doing the talking. We have decided to keep right on being touchy about this business, and we warn you not to argue with us about it should you meet us on the street. Anybody who cannot agree with us in this matter, gets a great big sock on the nose.

* * *

Revolutionary Novelties for the Winter Season

By the time these little paragraphs are immortalized in type, the robins and the hobos will have left for the South and radio broadcasting will have settled down into its fourth winter. Unless your hearing is very good, however, you probably missed the actual opening of the season. Of course, you no doubt noticed that the ice in the ice-box is lasting longer and that the bathing caps have been taken out of the five-and-ten-cent store windows, but, to reiterate, we're pretty sure that our scheming impressarios slipped their new season stuff over on you without your being any the wiser. This simply goes to show that broadcasting is troubled as much by its anaemia in the winter season as in the summer season and that a radio impressario runs true to form summer or winter.

If we ran a studio, we'd put on a "grand opening night" in the middle of November if for no other reason than showing that broadcasting was not wandering about with a bad case of amnesia. The trouble with the business now is that it invariably forgets where it is going but usually remembers where it was last week and last year. We recently decided that it has settled down into a vicious habit and that it is practiced as assiduously as any bad habit can be practiced. It is as consistent and as faithful as grandma is with her knitting.

The results of a recent canvas of the studios wherein our dashing young managers were asked to reveal their winter plans, will help to convince you that our appraisal is a fair one and that, further, broadcasting will be doing business at the same old stand in the same old way for many years to come.

WAAM—"The evening entertainment will be sufficiently diversified to attract those of varying tastes."

That's a big improvement, isn't it?

WBBM—"No program will lack orchestral entertainment. Every twenty minutes the listeners will be assured of orchestral music that will be good and different."

Burgess Laboratories

A BABY TRANSMITTER THAT COVERS 1,800 MILES

Only five pounds in weight and using less power than a two-cell flashlight is this transmitter of Phil Zurian of (9EK-9XH) of Madison, Wis. But it has been big enough for two-way communication with Massachusetts, New York and Mexico City.

Well, that's something to look forward to.

WCAP—"During the winter WCAP will present a well-balanced series of programs consisting of the better grades of music both vocal and instrumental. Educational talks will be used in proper proportion."

You'd better get those new "B" batteries.

WCBD—"WCBD will pursue the same general policy followed during the two and more years it has been in the broadcast field."

We roast our peanuts in the good old-fashioned way.

WCCO—"With two cities with a combined population of approximately a million and the entire Northwest looking to the station as its own, WCCO has a large field from which to draw its talent."

Go West, young soprano, and grow up with WCCO.

WCTS—"We have our own WCTS orchestra and are glad to furnish the public with whatever music it desires, classical or jazz."

There's somebody that'll play "By the Waters of Minnetonka" for you.

WEMC—"Specializes in classical and semi-classical music, lectures and the old-time songs and hymns."

Ma and pa will like that, won't they?

WFI—"During the winter, WFI will continue with classical music and a reasonable amount of dance music."

As faithful as a new pair of garters.

WHAS—"For the ensuing twelve months, we shall have a greater diversity of programs including a wider news bulletin service and sports service."

Diversification, that's the thing.

WHN—"WHN will follow along its customary policy of 'The station of Human Interest,' serving the masses rather than the classes."

That's the kind of stuff that goes over big out here in the Bronx.

WHT—"Our educational and cultural programs are broadcast for our Woman's Clubs numbering many thousands. The classics are emphasized during the period from seven to eight. A straight varied program is broadcast from ten-thirty until midnight."

Culture for the ladies. That's a big idea.

WLIT—"WLIT aims to broadcast a comprehensive educational program this winter."

We'll eddycate this country or bust.

WMBB—"WMBB's hours of broadcasting at present are from 7 to 8 P.M., at which time a semi-classical program by the Trianon Ensemble of string instruments and vocal artists is broadcast, and from 9 to 11 P.M., when a popular program by the Trianon Orchestra and vocal artists is broadcast."

The great Trianon Ensemble in different moods.

PWX—"We propose during the coming season when the static has disappeared to continue our usual routine."

Cuba getting its bad habits from America.

KOA—"Dramatic productions will continue to have a large place on our programs. Debates on serious topics will be arranged and we are considering establishing an open forum."

KOA caught in the act of thinking.

WRNY—"WRNY is now in the process of being departmentalized. A repertoire company is in formation. The whole time that WRNY will be on the air will be made into a permanent though flexible schedule which will become as familiar to listeners as breakfast, dinner and supper. We desire to make it possible for listeners to know just what they are going to hear at any time this week, next week or a month in advance."

Well, what have we been telling you right along? Oh, dear.

WSAI—"WSAI will feature more symphonic music during the coming season. However, a mixture of jazz will be added to satisfy those who prefer a lighter type of entertainment."

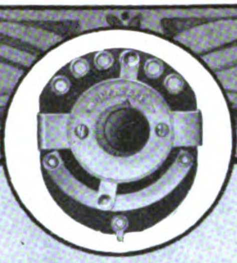
There's a case of clear thinking for you.

KFWB—"KFWB program will have variety, no special form of entertainment being shown preference."

Another member of the "National Association for the Maintenance of Variety."

WTIC—"Connecticut's only class B station will continue to comb the state for instrumentalists, singers and ensemble organizations as it has in the past."

A whale of a chance for the music teachers in Connecticut.



Grebe
Volume
Control

Controlling Audio Amplification in a New Way

WITH the Synchrophase, volume is controlled by an exclusive feature which makes possible six graduations of volume without changing the character of the sound. This is done gradually and not by the abrupt and distorting stage-to-stage method common to most receivers.

Sound can thus be modulated at will to please the ear.

Ask your dealer to demonstrate this and other Grebe features

A. H. GREBE & CO., Inc.
Van Wyck Blvd., Richmond Hill, N. Y.
Western Branch: 443 So. San Pedro Street, Los Angeles, Cal.

The GREBE SYNCHROPHASE

TRADE MARK

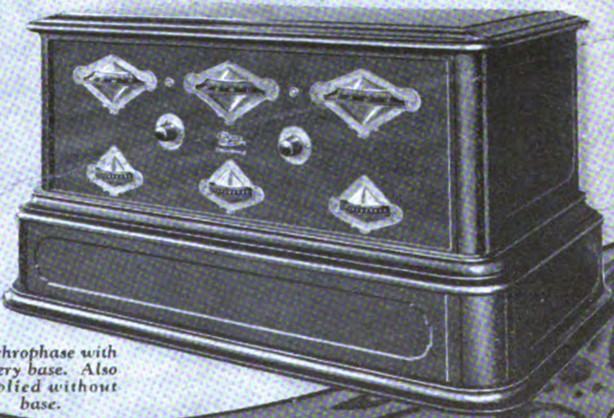
This company owns and operates station WAHG

Exclusiveness is a virtue only as it benefits others.

Doctor Mu

GREBE RADIO
TRADE MARK
Reg. U. S. Pat. Off.

All Grebe apparatus is covered by patents granted and pending.



Synchrophase with battery base. Also supplied without base.

PAGES WITH THE EDITOR

EVEN at the risk of stepping on the toes of certain radio interests and conflicting with the many and varying opinions in regard to the more or less vague group of difficulties that are classified under the general term "the broadcasting problem," POPULAR RADIO is plunging into the subject with some constructive suggestions—beginning on page 3 of this issue.

* * *

No one can arbitrarily put forth a scheme or a plan that will make the problems that confront the broadcasting stations dissolve. They are too many and too involved to be dispersed so easily. The radio industry is undergoing readjustments and developments that are akin to growing pains. And its problems are more likely to be solved, not so much by untried theories and schemes, as by modifications that are gradually brought about by the essentially practical laws of economics.

* * *

THE article starting on page 3 does not propose any untried plan for solving the broadcaster's problems; it merely points out some of the probable changes that will be brought about as the result of experiments that have been and are now being successfully made, and that appear to offer grounds for belief that a plan is being worked out that will benefit the broadcaster and the listener alike.

* * *

WHILE one hesitates to make dogmatic predictions concerning radio, the absurdities of over-caution may not be ignored. Which brings to mind the following essay (attributed to a foreigner in a Chicago night school), which is sufficiently devoid of flat-footed statements to commend itself to the most circumspect.

* * *

"WHAT a queer bird the frog are,
When he sit he stand, almost.
When he hop he fly, almost.
He ain't got sense hardly.
He ain't got no tail hardly, either.
He sit on what he ain't got, almost."

* * *

"YOUR timely attention to the excess of religious propaganda by radio deserves the acknowledgment of every American with sufficient brains and progressiveness to provide himself with a receiver," writes Mr. Ford N. Orr, of Little River, Florida. "The idea of restricting the broadcasting by all stations promoted, operated or sponsored by any religious organizations to certain hours of Saturday night and Sunday, occurs to me as a fair solution."

* * *

AT last POPULAR RADIO is able to respond to the demands of its readers and present, in compact, revised and up-to-date form, the complete list of radio circuit diagrams that was run serially in eleven issues of this magazine, under the title "100 Best Hook-ups."

* * *

BEGINNING on page 17 the reader will find this modernized record of diagrams under the title, announced last month, "The Best 101 Hook-ups." POPULAR RADIO believes that this list includes the most efficient and the most serviceable hook-ups that have been developed to date. *Keep this list for reference.*

* * *

"I HAVE been a POPULAR RADIO fan for almost three years, but have never read in any radio publication as interesting an article as 'Can Man Release the Enormous Energy in the Atom?' by T. F. Wall in POPULAR RADIO for May," writes Mr. George H. Liesenberg, of New York. "Such articles as that are helping to promote interest in the scientific world among the most intelligent group of radio fans—which means POPULAR RADIO readers."

* * *

RADIO fans who pride themselves on the superlative qualities of their pet receiving sets are challenged to a friendly competition by Mr. John Isler, of 906 Bloomfield St., Hoboken, N. J. Here are the particulars as he defines them:

* * *

"IT IS now approximately six months since I constructed the Cockaday Four-circuit Tuner with resistance-coupled amplification, described in your October, 1924, issue. Since then I have had perfect radio reception at all times.

* * *

"I BELIEVE that I have experimented with as many different radio circuits as any average home-builder, from crystal set to superheterodyne. The results I obtain with the Cockaday are so far superior to any of the others that there is absolutely no comparison, either in reproduction, volume, selectivity or distance range. When I was able, during the winter months, to pick up the west coast stations I was agreeably surprised; but when, during April and May (static permitting) I obtained clear loudspeaker reception consistently from Georgia, Texas and California, it convinced me that I have a radio receiver second to none. But the most pleasing feature is the undistorted clearness with which the circuit sends forth its reproduction.

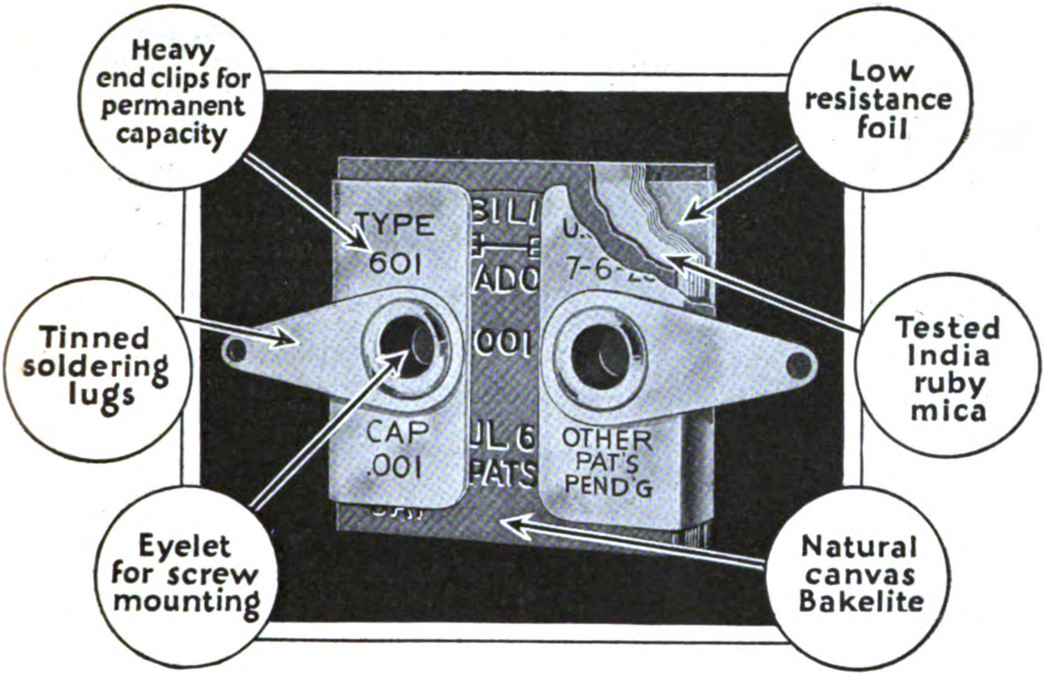
* * *

"PLEASE put me on record as issuing a friendly challenge to any type of receiver now on the market to equal the performance of my set in the same locality under identical conditions."

* * *

READERS who want to come to grips with Mr. Isler are invited to communicate with him direct.

(*Continued on page 6*)



What makes for efficiency in fixed condensers?

This diagram indicates the efficient details of construction that have made Micadons the standard* fixed condensers of radio.

Dubilier engineers have developed these standard condensers of accurate and permanent capacity. Micadons are known the world over—and are used in 90% of all radio sets.

***Standard**—*anything recognized as correct by common consent . . . of a high degree of excellence.—Webster*

Dubilier

CONDENSER AND RADIO CORPORATION

(*Continued from page* 4)

From a photograph made for POPULAR RADIO

OLD DR. POPULAR RADIO IN THE BOYS' WARD

"This boy," writes Mr. Preston T. Slayback, the Business Executive of the Los Angeles Orthopaedic Hospital-School for Crippled Children, "is a most enthusiastic and well-informed radio fan—and is, of course, a constant reader of POPULAR RADIO. *He was made very proud and happy when he was told that this photograph, showing your magazine on his bed, was to be sent to you, with an expression of thanks to you for the pleasure your magazine gives him and the other boys who are in the same ward with him in our hospital."*

* * *

THE eminent British statesman Gladstone used to subscribe to American magazines not only for the purpose of looking over the articles contained in them, but also to read the advertising pages. For in them, he said, he found reflected the activities and the industries and the needs of the American people.

* * *

IN similar spirit American radio fans are reading the advertising pages of POPULAR RADIO—because they find in them what is, in effect, the best and most carefully tested and consequently the most dependable of all radio apparatus.

* * *

ONE of our advertisers, for example (A. Hall Berry of New York), writes: "For more years than I like to admit I have been engaged in selling and advertising things, electrical and kindred lines. I have been accumulating experience in practically every department of the broad field of advertising and selling, but never, as advertising and sales manager for one of the largest electrical manufacturers in the world, as sales manager for two prominent advertising agencies in this country and as selling and advertising manager for a smaller but prominent manufacturer of electrical products, have I seen a quicker or more consistent response to advertising than has resulted from my small advertisement in POPULAR RADIO."

* * *

POPULAR RADIO, which created the idea of the silver cover which has distinguished the magazine from its earliest issues, has been tendered a subtle form of flattery—if imitation is flattery, as the poet tells us. "Radiofonia," a radio journal published in Rome, Italy, appears with its April 20 number enclosed in a silver cover!

* * *

"THE material in POPULAR RADIO is splendid. I have seen so much of thin and unauthoritative radio magazine stuff in current newspapers that it is a real adventure to see well written articles by the men who are advancing radio."

—COMMANDER FITZHUGH GREEN, U.S.N.

* * *

ANOTHER scientist of world-wide renown has joined the small but distinguished list of contributors to POPULAR RADIO—Sir William Bragg, K.B.E., D.Sc., F.R.S., M.R.I., Fullerian Professor of Chemistry at the Royal Institution of England and Director of the Davy-Faraday Research Laboratory.

* * *

SIR WILLIAM will contribute a series of articles on the atom—a phase of electrical science that is becoming of increasing import to radio. The first article of this series will appear in a near issue.

* * *

"I would not trade my subscription to POPULAR RADIO for a two weeks' vacation, nor trade my four-circuit receiver for any other that I have ever heard."

—DR. H. C. FOYLER, *Portsmouth, O.*

* * *

IN the next number will appear the latest contributions to the radio art by the POPULAR RADIO LABORATORIES—"How to Build a 5-Tube Receiver with Simplified Control."

Kendall Banning

Editor, POPULAR RADIO

Selectivity

—the most important function of a radio set

Binocular Coils

Sensitivity—yes.

Clarity of tone—surely.

But *selectivity*—that is the true test of performance.

The extreme selectivity of the Grebe Synchrophase has been made possible by the *Binocular Coils* which, because they have no field, are unaffected by impulses from undesired stations. They keep the set automatically balanced against such interference.

These Binocular Coils are exclusively Grebe, as are also the *Grebe S-L-F* (straight line frequency) *Condensers* and *Grebe Volume Control* which are outstanding features of the Synchrophase.

Ask your dealer to demonstrate these features or write us

A. H. Grebe & Co., Inc., Van Wyck Blvd., Richmond Hill, N.Y.
Western Branch: 443 So. San Pedro St., Los Angeles, Cal.

The GREBE SYNCHROPHASE

TRADE MARK

This Company owns and operates stations WAHG, WBOQ; also mobile and marine low-wave re-broadcasting stations.

The true worth of a machine lies not in its appearance but in its performance.

Doctor Mu

GREBE RADIO
TRADE MARK
REG. U.S. PAT. OFF.

All Grebe apparatus is covered by patents granted and pending.

Also supplied with base for batteries

PAGES WITH THE EDITOR

The Wireless Age to Be Combined with POPULAR RADIO

BEGINNING with the September number—published August 20—the oldest and one of the best and most widely known radio magazines in the world, *The Wireless Age*, will be consolidated with POPULAR RADIO.

* * *

THE consolidation marks the most important single advance that POPULAR RADIO has yet made in the publishing field, and establishes this combined magazine as the oldest, as it has been the most authoritative radio periodical, and one of the most widely circulated radio monthly magazines in the world.

* * *

To the strength of POPULAR RADIO will now be added the editorial resources of *The Wireless Age*—including not merely such material considerations as valuable contributions and a large list of subscribers, but also long established contacts with the world of science—contacts to which the successful career of *The Wireless Age* has been largely due. These assets now merge with this magazine.

* * *

THIS consolidation, however, will not otherwise alter the editorial policy of POPULAR RADIO, *nor affect the absolute independence of action that has marked this magazine from its beginning.*

* * *

The Wireless Age, the pioneer magazine in the radio field, was established in 1911 under the name of *Marconigraph* by the Marconi Wireless Telegraph Company of America. One year later the name of the magazine was changed to *The Wireless Age*.

* * *

FROM 1911 to 1923 *The Wireless Age* was edited by J. Andrew White, who built up the publication from a 16-page pamphlet to a 100-page magazine. During that period it has recorded every activity in the radio field, from the original Marconi experiments across the Atlantic and the pioneer wireless installation on shipboard to amateur activities everywhere. In recent years it has featured predominantly the broadcasting phase of radio, and it was to devote himself to this that its editor, Mr. White, gave up his editorial duties. Today Mr. White is perhaps the most popular sports announcer in the country.

* * *

WHEN the Marconi Wireless Company of America was taken over by the Radio Corporation of America in 1919, the publication of *The Wireless Age* was in turn taken over by The Wireless Press, Inc., a subsidiary company of the Radio Corporation of America. This subsidiary company was headed by General James G. Harbord, President of the Radio Corporation of America.

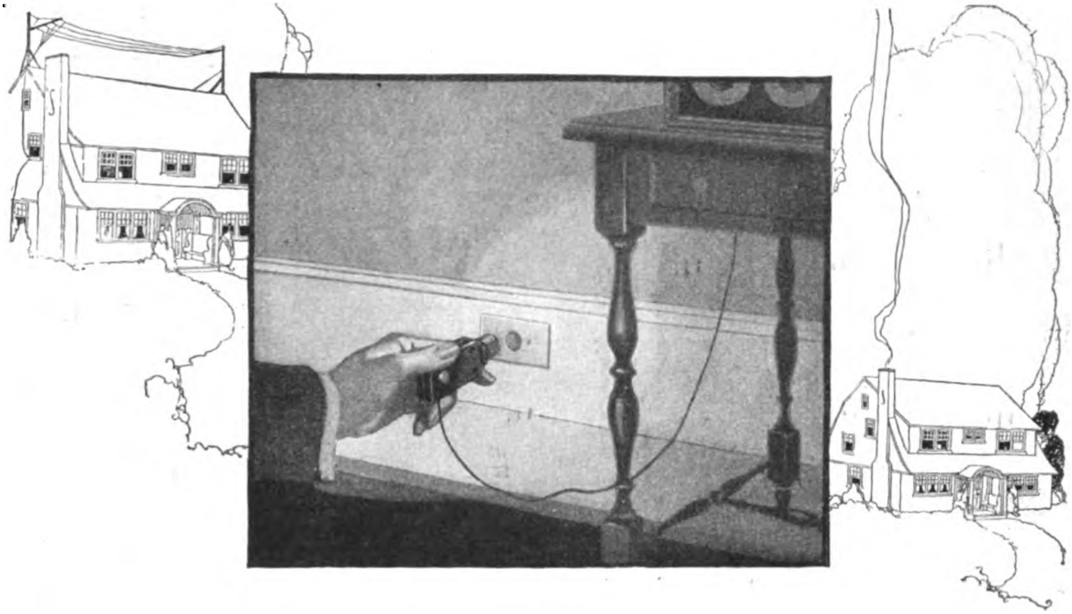
* * *

As the Radio Corporation of America has grown and its activities vastly developed, it finally reached the point where it concluded that it should concentrate in its highly specialized sphere and to dispose of its magazine interests entirely. So after careful consideration, the directors of The Wireless Press, Inc., selected POPULAR RADIO as the magazine that is best equipped to fulfill the obligations of *The Wireless Age* to its friends and readers.

* * *

WITH the next issue, therefore, this magazine will greet its largely increased army of subscribers and readers under the title of

POPULAR RADIO
with which is combined
The Wireless Age

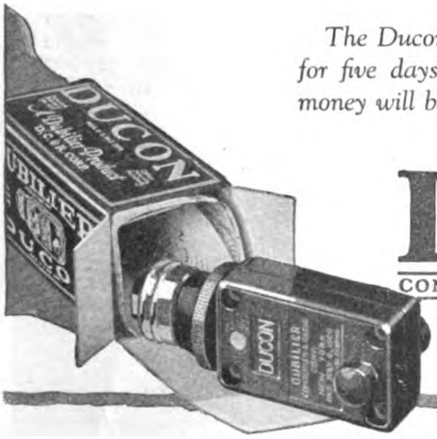


The $1.50 Ducon— and no antenna!

A small Ducon screwed into a light socket—or a cumbersome, unsightly aerial? Surely a Ducon! It's so inexpensive—so easy to use—so sure in its results.

Take home a Ducon today—and hear tonight's best programs!

The Ducon is sold by all reliable dealers. Try one for five days. If it is not thoroughly satisfactory, your money will be refunded.



Dubilier

CONDENSER AND RADIO CORPORATIO

PAGES WITH THE EDITOR

(*Continued from page* 4)

Sir William Bragg, who contributes to this number of Popular Radio the first of a series of articles on the atom, is not only one of the most distinguished scientists in the world, but one who is peculiarly gifted in the art of presenting scientific information in terms that the layman can easily understand. As evidence, turn to page 159.

* * *

The exclusive American serial rights of this series of articles have been obtained by Popular Radio by special arrangement with *The Illustrated London News*, in whose name the copyright on the drawings has been reserved.

* * *

"In your feature *What Set Shall I Buy?* in the June issue, you give the cost of our Model 20 Receiver as $100 'complete,'" writes Mr. F. W. Kulicke of the Atwater-Kent Manufacturing Co. of Philadelphia. "On account of this," he continues, "one of our dealers in Fitchburg writes that one of his customers refuses to pay because he thinks that the $100 includes complete equipment for installing. . . . In order to avoid similar misunderstandings, we suggest that you give the price of $100 as being 'less equipment.'"

* * *

The suggestion is hereby adopted and carried into effect. In some unexplained way the phrase "less equipment" was omitted from the price as published in our June issue—with resultant complications.

* * *

In the July number of Popular Radio appeared a short item, "Radio Interference from Clouds of Steam." It has elicited an interesting commentary by Mr. A. Neal of Pando, Colo., who writes:

* * *

"Some years ago, in a railroad station where I was located, a string of several telegraph wires passed diagonally across and over the main track less than fifty feet from the office end of the depot. You are no doubt familiar with a telegraph switchboard; a ground strap is located across the tops of the wire straps and separated from them by only about the thickness of a piece of heavy writing paper. This is a lightning protection for the instruments.

* * *

"Occasionally I noticed that a heavy freight locomotive, passing under these wires and working hard, caused a stream of static to jump across the gap between the ground and wire straps; it continued during the time the smokestack was directly and nearly directly under the wires and sounded like a miniature machine gun in action.

* * *

"At the time I attributed this action to some freak condition of the atmosphere. Now I am wondering if it was not caused by excessive moisture in the exhausted steam. Because of condensed steam in the cylinders a locomotive sometimes exhausts quantities of very small drops of water, drops so small that the soot-laden stains they leave on everything that gets in the way are about the size of a pin-head.

* * *

"More recently in an office where the wires (including a dispatcher's telephone circuit) were brought to the office in a cable about the tracks, I noticed that an engine standing or passing under this cable while 'popping off,' that is, while steam was escaping through the safety valve, produced a peculiar interference in the phone; it sounded something like a series of two-toned vibrations. Steam escaping through a safety valve generally does so with an unpleasant intermittent movement; 'popping off' gives a very good idea of the sound.

* * *

"I mentioned this action of the phone to the train dispatcher one day, and he told me that sometimes he knew from noises in his phone, when a train was passing a certain point where the wires crossed over the track between two certain stations of his district.

* * *

"Perhaps other readers of Popular Radio, located in railroad offices, particularly those that use telephones, have noticed interference from passing trains."

* * *

When the feature "100 Best Hook-ups," which ran serially in Popular Radio last year, was revised and brought up to date for publication in its entirety in the July issue—in response to the demands of our readers—it bore the somewhat modified title of "101 Best Hook-ups."

* * *

It was not until the July number had gone to press that the Editor was informed that a year preceding, Mr. M. B. Sleeper, the well-known radio expert, had published an excellent pamphlet under the title "101 Receiving Circuits."

* * *

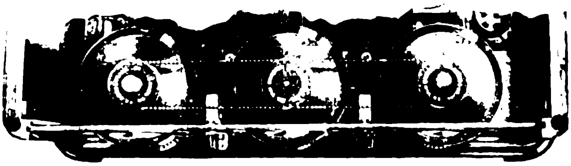
That Popular Radio should have selected the specific number "101" without knowledge of Mr. Sleeper's use of the same numeral, was entirely a coincidence. But as Mr. Sleeper is shortly to publish a revised edition of his pamphlet, the Editor is glad of the opportunity to credit Mr. Sleeper with the prior use of the numeral "101"—and to extend to our readers Mr. Sleeper's assurance that the new edition will be better than the old one!

* * *

In the next issue Mr. John V. L. Hogan will contribute a timely article on "How to Improve Broadcast Reception"—written for the specific purpose of advising the broadcast listener.

Kendall Banning

Editor, Popular Radio



Another exclusive Grebe feature: One dial can operate all three—or they can be set separately at will.

Again Grebe steps ahead—

S-L-F Condenser

The Synchrophase now has One, Two or Three-dial Control

THE three condensers operate from one dial—or separately at will. This first real, flexible form of "unit-control" marks another milestone on the road of Grebe leadership.

The new Synchrophase has the same *Binocular Coils* which give that unusual "selective sensitivity" so universally prized; the same Straight-Line-Frequency Condensers that make accurate tuning easy.

Ask your dealer to demonstrate; then compare

A. H. Grebe & Co., Inc., Van Wyck Blvd., Richmond Hill, N. Y.
New York Office: Steinway Hall, 109 West 57th Street
Western Branch: 443 So. San Pedro Street, Los Angeles, Cal.

This company owns and operates stations WAHG and WBOQ: also mobile and marine low-wave rebroadcasting stations.

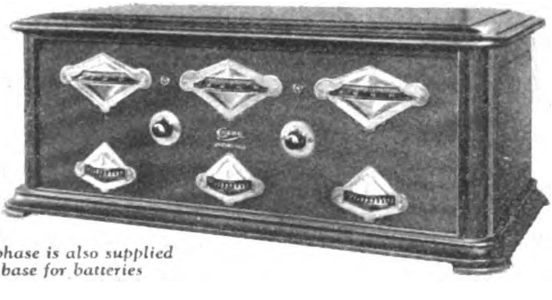
GREBE SYNCHROPHASE

— TRADE MARK —

"Get rid of small wisdom and great wisdom will shine upon you."
Chuang Tsu

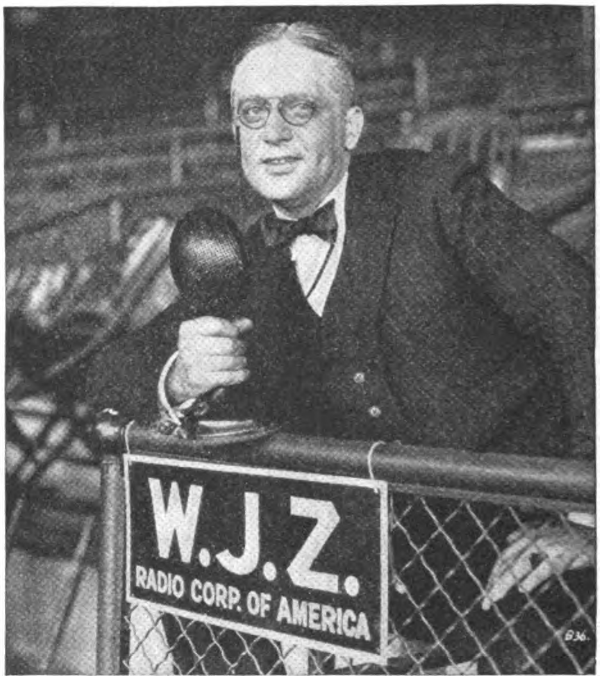
It is great wisdom to buy the Synchrophase.

All Grebe apparatus is covered by patents granted and pending.



Synchrophase is also supplied with base for batteries

PAGES WITH THE EDITOR



Radio Corporation of America

"NO COMBINATION COULD BE MORE IDEAL THAN THE COMBINATION OF THE *WIRELESS AGE* WITH *POPULAR RADIO*"

With this issue THE WIRELESS AGE, *the oldest radio magazine in the United States, is consolidated with* POPULAR RADIO. *Mr. J. Andrew White, for ten years the popular editor of* THE WIRELESS AGE *and known to radio fans throughout the country, takes this occasion to welcome his former readers to the large and growing army of readers of* POPULAR RADIO. *The Editor takes pleasure in calling upon his friend Mr. White for a few remarks!*

The Dean's Declamation

ALTHOUGH the surroundings are unfamiliar, looking up from this page into the eyes of old friends gives me the comfortable feeling of having strayed into the hearthside circle after being far afield for a time. If home is where the heart is, then I have never gone away; for nothing is dearer in the memories I have stored up than the many happy years when it was my good fortune to guide and govern feeble footsteps into radio for a host of loyal followers of that brave little pioneer publication, *The Wireless Age*.

* * *

IT is a very easy thing to be sentimental about old associations, and it doesn't embarrass me a bit to say that on an occasion like this there is no little emotion welling up within me.

* * *

As an Editor, there were thousands among my readers I counted as my friends. We wrote to each other, we met occasionally; neither, as often as we would have liked to; but as years rolled by and the same familiar names kept repeating themselves on the subscription lists there was no resisting the feeling that we were welded into one large but never cumbersome family.

* * *

AND now this move into a new community, where there will be more room for the growth of the true ideals and high purposes that served so well in cottage days and made the mansion possible.

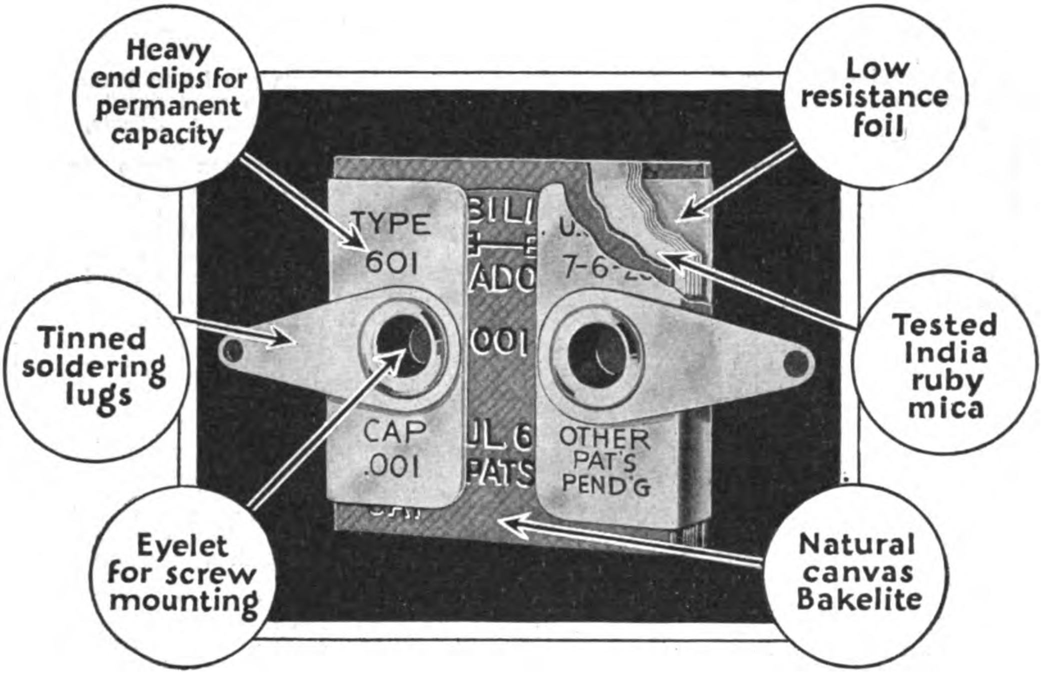
* * *

GOOD neighbors, these POPULAR RADIO folk! They looked like it at the beginning and they have proved it since. A happy culmination of the romance in radio, that is the way I see it; the words consolidation and combination seem too cold.

* * *

POPULAR RADIO and *The Wireless Age* have always had so much in common, interests and

(*Continued on page* 6)



What makes for efficiency in fixed condensers?

This diagram indicates the efficient details of construction that have made Micadons the standard* fixed condensers of radio.

Dubilier engineers have developed these standard condensers of accurate and permanent capacity. Micadons are known the world over —and are used in 90% of all radio sets.

****Standard**—anything recognized as correct by common consent . . . of a high degree of excellence.—**Webster***

Dubilier

CONDENSER AND RADIO CORPORATION

PAGES WITH THE EDITOR

(*Continued from page 4*)

aims identical—I simply can't picture their coming together in the light of anything as stiff and formal as is suggested by the phrase, a merging of corporate property. No, it may be whimsical, but I see that first born brain-child wedded to the big boy next door, and hordes of friends welcoming the new communion of interest.

* * *

I LIKE the idea of these two magazines as one. No combination could be more ideal.

* * *

I AM proud of the mutual respect in which the staffs of each have held each other, and in every way I look for the readers to come out ahead in the newer, bigger and better magazine resulting from a fusion of interests identical in purpose but characteristically individual.

* * *

PERSONALLY, I feel more than a tinge of regret that I can have no hand in fashioning the new periodical; it is a task worthy of any man's finest effort; but fate eased the editorial blue pencil out of my fingers some two years ago, and it looks that it might be for all time, for the growing pains of infant broadcasting allow of no digressions into the pleasant paths of journalism.

* * *

So I shall stand aside and envy Kendall Banning—who unquestionably will do a better job than anyone else could, anyhow. To him, success. To you, congratulations.

* * *

FOR myself, it is but a step back to the ranks of interested readers, whence I came, just for an occasion which seemed to call for a verbal handshake all around.

* * *

GLAD to have been with you for these few minutes—73s for now and all time.

J. ANDREW WHITE

* * *

BUT the Editor has no intention of letting Mr. White slip off the editorial harness quite so easily. Since Mr. White wrote the above he has accepted the Editor's invitation to conduct the "Broadcasts" department of this magazine—a department that will give him the opportunity of keeping our readers informed of the progress of radio throughout the world.

* * *

So if you turn to page 294 of this issue, you will find Mr. White's department, written in his own characteristic vein—and illustrated with a portrait of the "Major" (as he is popularly known) at the head!

* * *

HERE is a letter that makes the Editor appreciate the disadvantages of being confined in an editorial sanctum in New York: "You may be sure that I am not going to miss a single number of POPULAR RADIO. It is the only radio magazine that thinks of the reader *first.* If you are in Atlanta just let me know and I will try to show you a good time."

—MORRIS DORSEY, *Atlanta, Ga.*

* * *

ON page 68 of POPULAR RADIO for July appeared some data concerning the Type C receiver of the Standard Radio and Electric Company. But the picture that accompanied it, as well as the title, applied to the Standardyne receiver made by the Standard Radio Corporation—an entirely different concern with a name that is somewhat similar. The data concerning the Standardyne receiver, accompanied by a picture of the set, appears in the present installment of the "What Set Shall I Buy" series.

* * *

To the cynics who insist that the broadcasting of an event adversely affects the paid attendance, the extraordinary success of the outdoor concerts given at the Lewisohn Stadium in New York by the Philharmonic Orchestra comes as both a refutation and a rebuke.

* * *

UNTIL the first of these great concerts were broadcast (an event that was initiated by POPULAR RADIO on August 11, 1922), the paid attendance at these concerts averaged between 6,000 and 7,000. As soon as the concerts were broadcast, the attendance jumped conspicuously—reaching the record figure of 20,000.

* * *

THAT is why the Philharmonic concerts are now broadcast regularly three times a week through WJZ. The reason is obvious. It pays.

* * *

WITH this issue POPULAR RADIO welcomes to its subscription list the subscribers of *The Wireless Age*—whose unexpired subscriptions will be filled by this magazine.

* * *

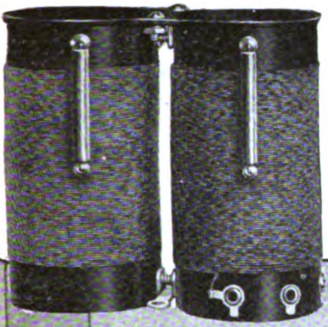
As POPULAR RADIO costs $3.00 a year, and as *The Wireless Age* cost $2.50 a year, an adjustment on all unexpired subscriptions to the latter magazine will be made on a pro rata basis. Thus, any subscriber who has a six months' unexpired term on *The Wireless Age* will receive POPULAR RADIO for five issues. And subscribers to POPULAR RADIO who have also subscribed to *The Wireless Age* will have their subscriptions extended proportionately.

* * *

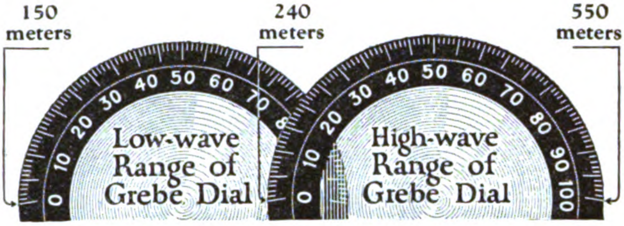
THE consolidation of these two subscription lists gives POPULAR RADIO far and away the largest subscripiton of any radio magazine in this country, according to the last available figures of the Audit Bureau of Circulation.

Kendall Banning

Editor, POPULAR RADIO



Grebe
Binocular
Coils



The Synchrophase Now Reaches from 550 Down to 150 Meters

THE Synchrophase, with the new Low-wave Extension Circuits, will receive all present and projected stations. It is really two receivers in one.

This great range is accomplished by means of an *automatic* switch which enables *one* dial to cover *two* wave ranges. The first, from 550 meters down to 240, corresponds to the practical tuning range of the usual receiver. The second overlaps this and goes down to 150 meters. Simply move the center dial past the 100 mark for the high range, and beyond the zero mark for the low range.

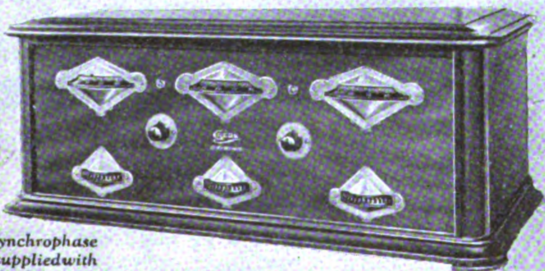
This low-wave reception opens up over 100 existing stations, broadcasting on less than 240 meters, and not reached by other sets. This will be especially valuable later, when stations generally begin to use lower wave lengths. The Synchrophase is thus equipped for the future.

Ask your dealer to demonstrate
this new feature; then compare.

A. H. Grebe & Co., Inc., Steinway Hall, 109 West 57th Street, N. Y. C.
Factory: Van Wyck Blvd., Richmond Hill, New York
Western Branch: 443 S. San Pedro St., Los Angeles, Cal.

This Company owns and operates stations WAHG and WBOQ; also low-wave rebroadcasting stations, mobile WGMU, and marine WRMU.

The
GREBE
SYNCHROPHASE
TRADE MARK REG. U.S. PAT. OFF.



The Synchrophase is also supplied with base for batteries.

GREBE RADIO
TRADE MARK REG. U.S. PAT. OFF.

All Grebe apparatus is covered by patents granted and pending.

It is written:
"Whoever can see three days ahead, will be rich three thousand years."
The purchaser of a Synchrophase now, will not be rendered unhappy by coming changes in broadcast ing methods.

Doctor Mu

PAGES WITH THE EDITOR

IN the next issue of POPULAR RADIO—for November—will appear for the first time an article on a subject of such importance that it may conceivably change the whole status of the radio art so far as broadcast reception in the home is concerned.

* * *

UNDER the title of "How to Build the Raytheon Plate-Supply Unit" will be described the construction of a full-wave rectifying and filtering unit. The model, which was developed in the Popular Radio Laboratory, provides for the use of a new tube—a tube that may have a far-reaching effect upon the methods of radio reception. For this remarkable unit utilizes the alternating current as the basis for the plate supply voltage to the receiving tubes.

* * *

IN other words, this newly developed unit is a so-called "B" battery eliminator that employs the new Raytheon tube—which is a development of the famous "S" tube.

* * *

THIS new unit operates directly from the 110 volt A.C. house-lighting lines. And it offers the first permanent solution of the problem of converting alternating current to non-pulsating direct current for receiving sets.

* * *

THE unit has been in the course of development by the Popular Radio Laboratory over a period of several months. But it was not until the unit satisfactorily met the most rigid of tests that it was "released for publication."

No radio experimenter can afford to miss the November number of POPULAR RADIO. If you are not a subscriber, ask your newsdealer to be sure to reserve a copy for you.

* * *

"$500,000,000 will be spent by broadcast listeners in the United States for radio sets this year."

* * *

THAT is the estimate made by the Copper and Brass Research Association—which has made a careful study of the radio industry and has come to some significant conclusions. Among them are the following:

* * *

THAT the money being spent for radio sets this year, 1925, is ten times greater than the amount spent for sets in 1922:

* * *

THAT by the end of the year 1925 there will be 5,000,000 receiving sets in use:

* * *

THAT if the 25,000,000 families in the United States can own 17,000,000 automobiles, at least that number will, in all likelihood, own radio sets:

* * *

THAT there are 12,000,000 families in the rural districts of this country, where the radio set is likely to find its highest appreciation, not only because of the entertainment it provides, but because of its essentially practical value in furnishing storm and frost warnings, market quotations and other knowledge useful to the farmer.

(*Continued on page* 6)

CONSTRUCTING ONE OF THE FINAL MODELS OF THE NEW PLATE-SUPPLY UNIT

The new Raytheon plate-supply unit—which will be described in the November issue—is the result of five years of experimental work on the filament-less tube and one year of experimental research work on the design of the electrical circuit, including the filter for producing a true direct current without hum. This picture was made in the POPULAR RADIO LABORATORY.

Super-Ducon

Price **$47.50**

Perfected with specially designed
RCA Tube

The Super-Ducon replaces the "B" battery, operates from the light socket (110 to 115 volts, 50 cycle A. C.) and is absolutely noiseless when properly installed.

Every radio man knows the results he gets when his "B" battery is at its best. The Super-Ducon gives him this top-notch volume *all* the time.

As now furnished, the Super-Ducon has a specially designed R C A tube—Rectron U. V. 196, which has an average life of more than 1,000 hours.

Tested and listed by the National Board of Fire Underwriters

Write for descriptive bulletin. Address—4377 Bronx Blvd., New York City

Dubilier

CONDENSER AND RADIO CORPORATION

PAGES WITH THE EDITOR

(*Continued from page 4*)

As Popular Radio has at various times pointed out, radio is destined to have a profound effect upon civilization—perhaps more than any other single invention of man.

* * *

No user of a receiving set can afford to miss the helpful and informative articles that are contributed to Popular Radio under the collective title of "How to Improve Radio Reception," by the eminent radio expert John V. L. Hogan. The article, starting on page 318 of this issue, deals specifically with the methods of cutting down interference.

* * *

In the next article of this series Mr. Hogan will describe the single control applied to the small antenna circuit (such as that shown in Figure 1 on page 000), and will take up the use of these coupled tuned antenna systems for increasing the selectivity of simple regenerative sets and of radio frequency amplifier receivers.

* * *

"In the August issue, on page 182," writes Alfred C. Brower, Jr., of South Orange, N. J., "you publish a picture of a radio-equipped ship. . . . It happens that the boat is named after its owner, my uncle; the correct name is not the *Charles Bower*, as you state, but the *Charles Brower*."

* * *

Your magazine is wonderful. Every number seems to be better than the last.

—Clint Robertson, *Denton, Tex.*

* * *

Which department in Popular Radio do *you* like best?

* * *

The Editor wants to know—and the best way to find out is to ask the opinions of our readers. Which department should be enlarged? Which one reduced? What new department might be added?

* * *

One of the departments which is steadily gaining in popularity and value—if the letters received from our readers are any criterion—is "In the World's Laboratories," which gives a monthly review of the progress in the field of radio throughout the world. Here, for example, is a typical commentary from a reader, Mr. H. J. Hinks, of London:

* * *

"During the last few months I have been reading with interest your magazine Popular Radio. It is with particular satisfaction that I note there exists a radio magazine to suit all classes of readers, and of the character such a magazine should be. It has been my privilege during the last few months to broadcast from the London station of the British Broadcasting Company, a series of lectures on radio, and I assure you that the department *In the World's Laboratories* has proved of great service to me in this work, especially on account of the references given."

* * *

"It is my opinion that Popular Radio is *the* Radio Magazine," writes Ray C. Poulson of Detroit, Mich. "All others could be eliminated and still the whole field covered would be covered, and in a comprehensive way. We are beginning to realize what a real contribution to the art and science of radio you are making through your laboratory and your staff; you are to be commended, too, for your editorial policies."

* * *

Ever since the publication of "Religion's Raid on Radio" in the January issue of Popular Radio—an article that stirred up a veritable hornet's nest of both praise and abuse—there has been a noticeable effort on the part of the church organizations to belittle the efforts that are being made to use radio for religious propaganda purposes.

* * *

"There are over 500 broadcasting stations in this country," writes Mr. M. D. Lyons, of St. Stanislaus Seminary, "but only ten of these are controlled by Catholic churches or educational institutions. The explanation of this apparent bashfulness is the fact that the very nature of the principal Catholic service, the Mass, requires the actual presence on the part of the Catholics.

* * *

"The few Catholic stations that are operated for religious purposes, six in number, are intended for the instruction of non-Catholics in matters of Catholic doctrine. . . .

* * *

"'The following is a list of Catholic broadcasters:

Villanova College, Villanova, Pa.
St. Louis University, St. Louis, Mo.
St. Patrick's Cathedral, El Paso, Tex.
Catholic University, Washington, D. C.
Marquette University, Milwaukee, Wis.
St. John's Church, Canton, O. Rev. E. P. Graham.
St. John's University, Collegeville, Minn.
St. Martin's College, Lacey, Wash.
Loyola University, New Orleans, La.
Paulists' Fathers, New York, N. Y.

* * *

Posssibly the objections that have been raised to the excessive religious matter that is being broadcast in certain sections have made the churches realize that the reaction is unfavorable not only to the radio interests but to the church interests themselves—as the article in Popular Radio pointed out.

* * *

Popular Radio believes that there is a proper and legitimate demand for the broadcasting of religious services and talks, just as there is a proper and legitimate demand for jazz, prize fight reports, grand opera and political debates. But in the words of Abe Potash, "too much is plenty."

Kendall Banning

Editor, **Popular Radio**

ONE OF THE GREATEST OF RADIO DEVELOPMENTS

Grebe "Colortone"

THIS tone control is, perhaps, the greatest of recent Grebe inventions.

Grebe "Colortone" enables you to alter to your taste, the quality of speech or music from high, thin pitch to deep, round tones with all the variations between. The Synchrophase is independent of the loud speaker's influence.

With the "Colortone" a complete range of tone characteristics is thus available and the best qualities of any loud speaker are brought out.

The "Colortone" makes it possible to suppress considerably the high pitch frequencies caused by heterodyne interference of one station with another and also to reduce, to a great degree, disturbances due to static.

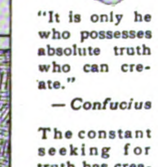
Ask your dealer to demonstrate this as well as the many other exclusive Grebe features; then compare

A. H. Grebe & Co., Inc., Steinway Hall, 109 West 57th St., N. Y.
Factory: Van Wyck Boulevard, Richmond Hill, N. Y.
Western Branch: 443 So. San Pedro Street, Los Angeles, Cal.

This company owns and operates stations WAHG and WBOQ; also low-wave rebroadcasting stations, mobile WGMU and marine WRMU.

The GREBE SYNCHROPHASE

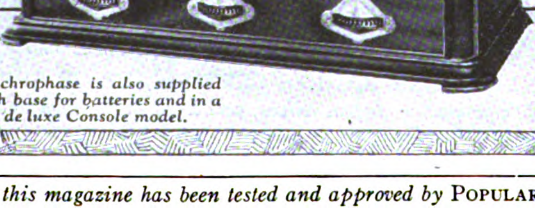
TRADE MARK REG. U.S. PAT. OFF.



"It is only he who possesses absolute truth who can create."
— *Confucius*

The constant seeking for truth has created the "Colortone" and other Grebe advances in radio reception.

Doctor Mu



Synchrophase is also supplied with base for batteries and in a de luxe Console model.

GREBE RADIO

All Grebe apparatus is covered by patents granted and pending.

PAGES WITH THE EDITOR

"ONE of the most valuable services that POPULAR RADIO has rendered to the radio industry," a prominent scientist recently told the editor, "has been the stabilizing of the industry through the medium of the tests made of radio apparatus in POPULAR RADIO LABORATORY."

* * *

THIS observation checks up with similar comments that have reached us from many sources—from radio amateurs, from broadcast listeners, from dealers, from manufacturers.

* * *

POPULAR RADIO'S policy of submitting to rigid test every piece of radio apparatus that is submitted to the laboratory, and of rejecting every piece of radio apparatus that does not meet the required standards, *and of refusing advertisements of all unsatisfactory apparatus,* has not only proven invaluable to radio fans by guarding them against inferior products, but has been of inestimable value to the manufacturers themselves, who have in many cases been able to improve their products through the expert advice and constructive suggestions of our laboratory staff.

* * *

UP to August 1, 1925, over 1,500 pieces of radio apparatus have been tested and approved. Of this number many were not approved until certain changes were made in them in accordance with recommendations of the laboratory. And many pieces of apparatus were rejected entirely.

* * *

NO advertisement is accepted by POPULAR RADIO unless the product or the service advertised is approved by the laboratory, and no advertisement is accepted that contains extravagant or misleading claims.

* * *

To every manufacturer whose product is approved is issued a POPULAR RADIO CERTIFICATE OF APPROVAL shown on this page. The original of this certificate is 13½ inches wide by 12 inches high, beautifully printed on a Japan vellum.

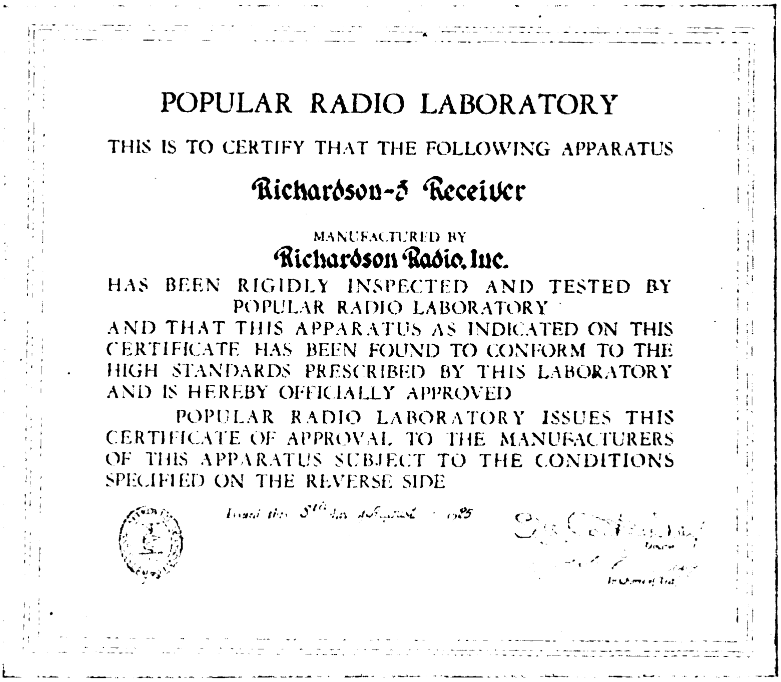
* * *

So valuable do manufacturers consider this certificate that the originals are almost invariably framed and hung in prominent positions in the sales rooms or offices.

* * *

AND in most instances, also, duplicate copies of this certificate are furnished to the salesmen. Experience has shown that the "sales resistance" of prospective buyers is appreciably lessened upon presentation of this proof that the apparatus has met the standards set by POPULAR RADIO LABORATORY.

(*Continued on page* 6)



POPULAR RADIO LABORATORY

THIS IS TO CERTIFY THAT THE FOLLOWING APPARATUS

Richardson-5 Receiver

MANUFACTURED BY

Richardson Radio, Inc.

HAS BEEN RIGIDLY INSPECTED AND TESTED BY POPULAR RADIO LABORATORY AND THAT THIS APPARATUS AS INDICATED ON THIS CERTIFICATE HAS BEEN FOUND TO CONFORM TO THE HIGH STANDARDS PRESCRIBED BY THIS LABORATORY AND IS HEREBY OFFICIALLY APPROVED

POPULAR RADIO LABORATORY ISSUES THIS CERTIFICATE OF APPROVAL TO THE MANUFACTURERS OF THIS APPARATUS SUBJECT TO THE CONDITIONS SPECIFIED ON THE REVERSE SIDE

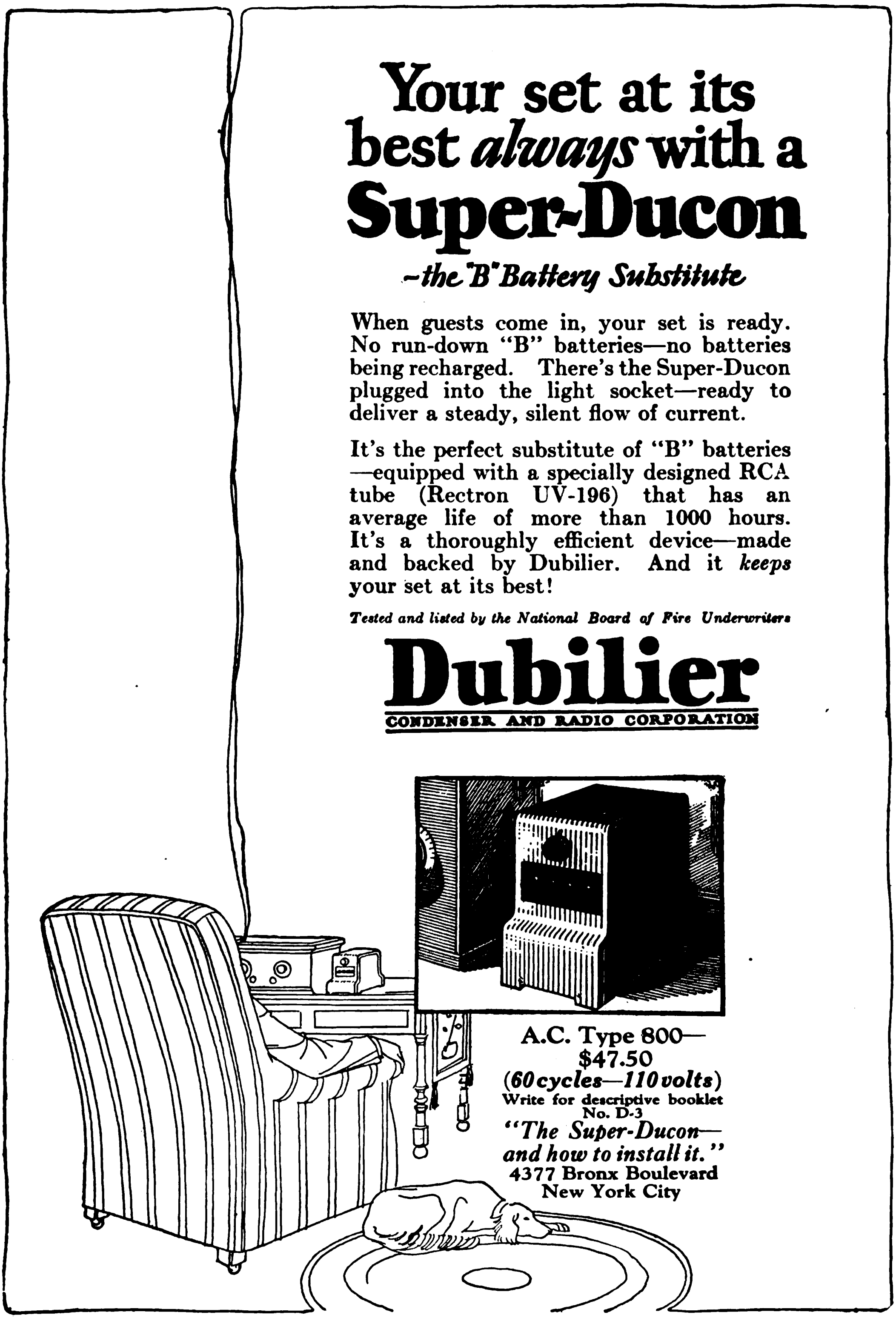
Issued this 5th day of August 1925

Director

In Charge of Test

POPULAR RADIO'S CERTIFICATE OF APPROVAL

The original is printed on Japan vellum, and is 12 inches high by 13½ inches wide. The manufacturer is authorized to use on the product approved the small oval silver imprint that is shown affixed in the lower left corner.



Your set at its best *always* with a Super-Ducon

—the "B" Battery Substitute

When guests come in, your set is ready. No run-down "B" batteries—no batteries being recharged. There's the Super-Ducon plugged into the light socket—ready to deliver a steady, silent flow of current.

It's the perfect substitute of "B" batteries—equipped with a specially designed RCA tube (Rectron UV-196) that has an average life of more than 1000 hours. It's a thoroughly efficient device—made and backed by Dubilier. And it *keeps* your set at its best!

Tested and listed by the National Board of Fire Underwriters

Dubilier

CONDENSER AND RADIO CORPORATION

A.C. Type 800—
$47.50
(60 cycles—110 volts)
Write for descriptive booklet No. D-3
"The Super-Ducon—and how to install it."
4377 Bronx Boulevard
New York City

PAGES WITH THE EDITOR

(*Continued from page* 4)

WHAT ONE MANUFACTURER THINKS OF POPULAR RADIO'S O.K.

The Sterling Manufacturing Company, manufacturers of a tube reactivator, sent in copy for an advertisement for the October issue of POPULAR RADIO. *But as the reactivator had never been tested and approved by* POPULAR RADIO LABORATORY, *we could not accept the advertisement until a sample had been sent to us. As we were nearing the closing date for the magazine, we wired the Sterling Mfg. Co. to send us one of the instruments and they, realizing the importance of getting it on time in order to have their advertisement run in the magazine, sent it by first-class air mail from Cleveland to New York, at a cost of $10.80 for postage.*

POPULAR RADIO LABORATORY makes no charge for making these tests. It makes no charge for the Certificates of Approval.

* * *

AND it makes no distinction whatever between manufacturers who advertise in POPULAR RADIO and those who do not.

* * *

THE testing of any radio part places the manufacturer under no obligation whatever to advertise in POPULAR RADIO. Indeed, many hundreds of pieces of radio apparatus have been tested and approved which have never been advertised and may never be advertised in POPULAR RADIO.

* * *

FURTHERMORE, every manufacturer of radio apparatus that is approved by POPULAR RADIO LABORATORY is authorized to use the small silver "Seal of approval" in his advertising and to stamp it into the product itself, or to attach the seal to it in the form of a label.

* * *

SO high are the standards that have been established by the laboratory, and so impartially have these tests been made, and so helpful have been the changes and improvements that have been suggested by the technical staff of the laboratory, that the POPULAR RADIO stamp of approval has been accepted generally as standard of merit.

AND it was this service—valuable alike to the buyer, seller and maker of radio apparatus—that the prominent scientist had in mind when he commented upon the important part that POPULAR RADIO has played in stabilizing the radio industry.

* * *

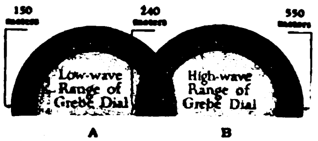
THE snapshot of Mr. John Hays Hammond, Jr., which appeared on page 218 of our September issue, proved to be in reality a portrait of one of Mr. Hammond's former assistants, taken during some of their experimental work in radio. To show that he harbors no ill will as the result of this photographic error, Mr. Hammond has not only sent the Editor an authentic portrait of himself but his opinion of POPULAR RADIO to boot. You will find them both on page 395 of this number.

* * *

IN the next number of POPULAR RADIO will appear a complete "How-to-Build" description of the latest and most important contribution of the POPULAR RADIO LABORATORY—the remarkable LC-26 radio receiver.

Kendall Banning

Editor, POPULAR RADIO

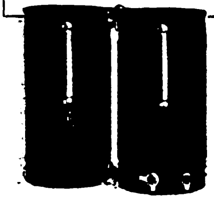


The high-wave reception range of the Grebe dial (B)—from 550 down to 240 meters—equals the practical tuning range of the usual receiver. The low-wave range of the Grebe dial (A) provides additional reception down to 150 meters.

Grebe "Colortone"

Flexible Unit Control

One dial operates two or all three; or dials may be adjusted separately, at will.



Grebe *Binocular* Coils
Reg U. S. Pat. Off.
and
Low-Wave Extension
Circuits

The Three Outstanding Radio Advances of 1925

YOU could not give or receive a finer Christmas gift than the Grebe Synchrophase.

Last year Grebe developed the fieldless *Binocular* Coils and *S-L-F Condenser.* This year even greater strides have been made in radio reception.

With the *Grebe "Colortone"* the quality of sound can be kept absolutely true and clear and is always under the listener's control, independent of the loud speaker's influence. This tone control also makes it possible to reduce, to a great degree, disturbances due to static and to suppress considerably the high-pitch frequencies caused by heterodyne interference of one station with another.

The *Low-Wave Extension Circuits* have widened the reception range so that over 100 low-wave stations not reached by other receivers can be tuned.

Flexible Unit Control gives one, two or three-dial control.

Both in range and quality of reception, the Grebe Synchrophase is far in advance.

Ask your dealer to demonstrate, then compare Grebe reception with that of other receivers

A. H. Grebe & Co., Inc., 109 West 57th Street, New York
Factory: Richmond Hill, N. Y.
Western Branch: 443 So. San Pedro St., Los Angeles, Cal.

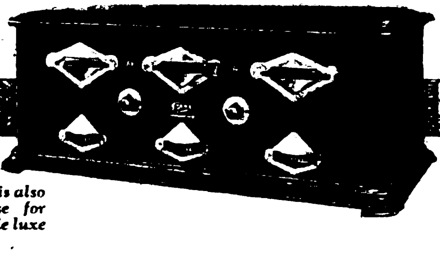
The GREBE SYNCHROPHASE
TRADE MARK REG U.S. PAT OFF.

This company owns and operates stations WAHG and WBOQ; also low-wave re-broadcasting stations, mobile WGMU and marine WRMU

"Take the lead and set an example of diligent toil."
—Confucius

Much toil and great diligence have made the Synchrophase worthy of first rank in radio receivers.

Doctor Mu



The Synchrophase is also supplied with base for batteries and in a de luxe Console model.

GREBE RADIO
TRADE MARK REG. U.S. PAT. OFF.
All Grebe apparatus is covered by patents granted and pending.

PAGES WITH THE EDITOR

THIS is the time of year when the radio fan—particularly the experimenter—is searching the most diligently for the "best receiver in the world."

* * *

EVERYONE demands a receiver that gives "truthful reproduction." Nearly everyone demands a circuit that is highly selective. Nearly everyone wants a receiver that is easy to tune. And a great many want to get long distance.

* * *

To develop a circuit that will meet these requirements better than they have ever been met before has been the aim of the POPULAR RADIO LABORATORY ever since it created the famous Cockaday Four-circuit Tuner—of which about a million have been built from designs furnished by this magazine.

* * *

FOR the past nine months the staff of the POPULAR RADIO LABORATORY has concentrated upon this task. During this period a need was found for radio parts that were better than anything on the market. So new and better parts were designed and built—and the radio art has been advanced and the broadcast listener has been benefited by just so much.

* * *

AT last the task was completed. And the complete report of it, including specific and detailed "how-to-build" plans, is contained in this number—beginning on page 495.

* * *

IT has been the unanimous opinion of the experts who have listened to this set and tested it that it represents the very latest and best word in receiver set design: that it furnishes the experimenter and the home-builder with the most efficient receiver that has ever been placed at his disposal.

* * *

AMONG the outstanding features of this set are:

It gives the clearest and most truthful of reproduction;
It is super-selective;
It is easy to tune;
It is capable of getting great distance;
It will not radiate;
It is beautiful in design;
It is easy to build—at a cost for parts not in excess of $63.50.

* * *

IN this receiver (designated as the LC-26), POPULAR RADIO has reason to believe that it has made an outstanding and substantial contribution to the radio art.

* * *

FOR so long has POPULAR RADIO been identified as "the magazine with the silver cover" (a cover scheme that this magazine originated nearly four years ago) that one would ordinarily conclude that this distinguishing feature would be reserved by other periodicals for POPULAR RADIO alone.

* * *

PERHAPS, however, with the purpose of basking in a reflected prestige, at least two foreign radio magazines have recently copied the silver cover idea. The first to do so was a French magazine; the latest to do so is "*Osterreichischer Radio Amateur,*" an Austrian monthly edited by Professor Anton Zeemann. Not only has our Austrian contemporary copied the silver cover, but it has even copied the June, 1925, design itself—even to the white lettering of the title and the black circle that contains the price-mark!

* * *

AN Australian and a Japanese radio magazine have gone further: they have reprinted entire articles from POPULAR RADIO—without credit, of course.

* * *

IF imitation is the ultimate of flattery, POPULAR RADIO is being overwhelmed with praise by our European imitators.

* * *

"THE new issue of POPULAR RADIO, which is the first of the combined issues of POPULAR RADIO and *Wireless Age*, is certainly wonderful. I did not believe it possible to improve POPULAR RADIO, so I am pleased to say that it was really a pleasant surprise. You certainly have my sincere good wishes for an increased membership, and I trust that your circulation will continue to grow right along."

—C. W. RILEY, JR., *Cincinnati, O.*

* * *

IRISH wrath was wreaked upon the head of the Editor when POPULAR RADIO for September reached its readers on the Emerald Isle. And all because of a little paragraph that was headed "The Irish Still Squabbling Over Their One Proposed Station," based upon an article which reached us through a news agency.

* * *

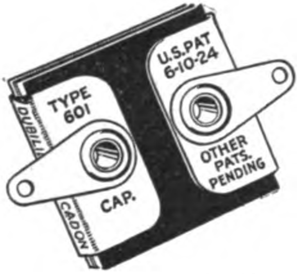
"IN the first place," protests Mr. Scott Hayward of Dublin, "the Irish are not squabbling, so there is no controversy at all concerning the question of broadcasting. And secondly, there are *two* proposed stations—not only proposed but decided upon—one for Dublin and one for Cork, in addition to the Irish station established for a considerable time at Belfast.

* * *

"FURTHERMORE, I would point out that the question before the Dail was whether Irish Free State broadcasting should be State controlled or left to private enterprise. State control was decided upon and the decision annoyed certain people who wanted the British Broadcasting Company to operate stations in this territory. I can only assume that it is by one such person that you have now been misinformed.

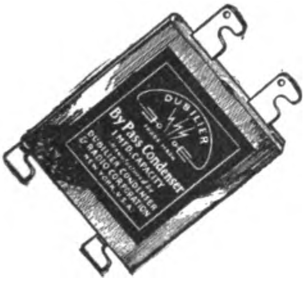
(*Continued on page 6*)

Buy with Confidence
Dubilier Devices

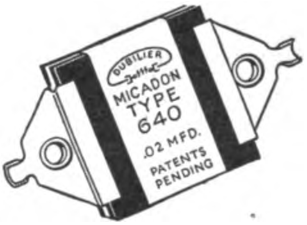


Micadon—the standard fixed condenser of radio.
35c to 75c

Ducon—the standard antenna socket plug. . . **$1.50**



By-Pass Condenser — smooths out fluctuations of "B" Battery current.
75c to $3.75

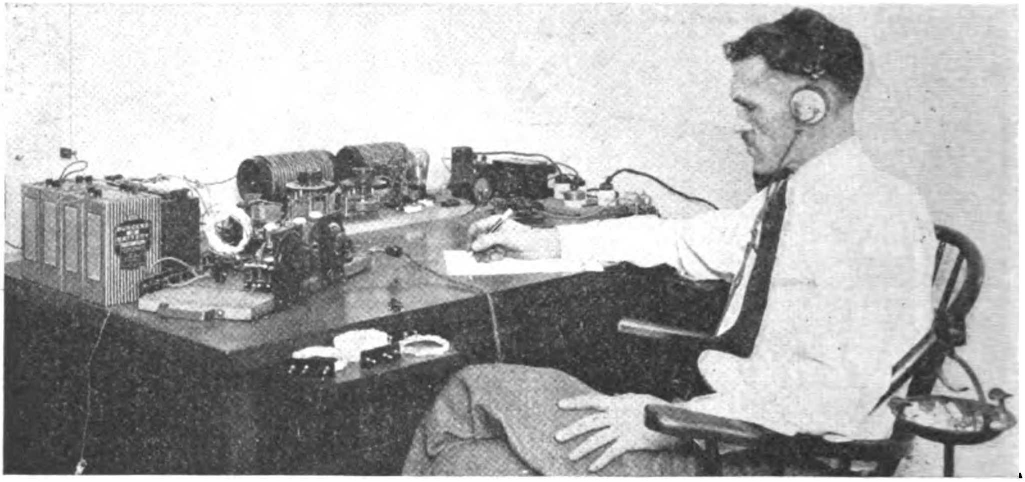


Micadon 640—the ultimate in accuracy and efficiency. Capacities .00025 to .02 Mfd.
40c to $1.75

Dubilier
CONDENSER AND RADIO CORPORATION

PAGES WITH THE EDITOR

(*Continued from page 4*)



POPULAR RADIO'S AMATEUR SHORT-WAVE TRANSMITTING STATION

This short-wave transmitter and receiver is in operation in the laboratory at the home of Mr. Taylor, of the* Popular Radio *staff. Using a single 7½-watt tube (UX-210), this transmitter has carried on reliable communication over a distance of 1,000 miles* In Daylight. *An article on its construction will appear in "In the Experimenter's Laboratory" of the February issue. The receiver shown at the left is that described in this department of the November issue but with another stage of audio amplification added; it has logged amateur stations in New Zealand, Australia, South America and a number of European countries. Its range is in excess of 10,000 miles.

"The erection and operation of the Dublin and Cork stations," continues Mr. Hayward, "are in the hands of the Minister of Posts and Telegraphs, who received the assent of the Finance Minister to his plans. These proceed satisfactorily. A Dublin site has already been acquired at the McKee Barracks and the erection is expected to commence very soon. The Minister for Posts and Telegraphs has recently announced that he will carry on this promise to have the Dublin broadcasting station working by Christmas."

* * *

The Editor is not only glad to publish Mr. Hayward's correction but also to congratulate the people of the Irish Free State upon the Christmas present that is on its way to them.

* * *

"I think that Popular Radio is the best radio magazine in circulation; one feature that I like especially is your system of having all the reading matter together, apart and separate from the advertisements. I think that your magazine is as nearly perfect as possible."

—Robert G. Denmead, *West Liberty, O.*

* * *

"I have had great admiration for your magazine since its first appearance," writes Mr. D. R. Clemons, an instructor in radio in Valparaiso, Ind., "and have always hoped that I could some day succeed in locating an article with you. There is a certain dignity about your pages that gives one a feeling of security in accepting the facts published there."

* * *

Accompanying Mr. Clemons' letter was the manuscript of an excellent article on coils—one of the best articles on the subject that Popular Radio has ever seen. And as it is based upon the author's original study, it contains valuable information that is not generally known.

* * *

This article will appear in a coming issue of this magazine—and it will be presented in a form that will meet with the approval of even the author himself!

* * *

"All broadcast listeners should be appreciative of Popular Radio's courage in protesting against the invasion of the home by militant religionists," writes Ames Nowell of Boston, Mass. "Religious services and lectures, *per se*, have a legitimate place in the radio world, but there is a limit to all good things."

Kendall Banning

Editor, Popular Radio

Real Progress in Radio

Emphatically Yes!

Radio IS marching forward, this season as before. But it is marching in a new direction.

Quality of Reception.

That is the big, new theme. And the new Jewett Receiver is its inspiration.

At last Radio commands a Receiver that is truly a Musical Instrument, by a manufacturer of experience in the musical instrument field.

Mere words cannot describe this new Jewett Quality of Reception. You must *hear* and understand.

So just visit an authorized Jewett Dealer and let him prove to you that here is a new kind of Radio—so different from the old as to create new standards and ideals.

For the first time, B-Battery current and resulting distortion have been completely barred from the speaker circuit.

You should know the story of this epoch-marking Receiver and its birth in the brains of our straight-thinking young engineers who refused to admit that it couldn't be done. Ask us for it.

"There Is No Substitute For The Best"

JEWETT RADIO & PHONOGRAPH CO.
5668 TELEGRAPH RD. PONTIAC, MICH.
Factories: Allegan, Mich.—Pontiac, Mich.
In Canada: Jewett Radio-Phonographs, Ltd., Walkerville, Ont.
Export Sales Offices: 116 Broad Street, New York City

The Jewett Receiver

The Jewett Superspeaker

The Jewett Superspeaker Console

The Jewett Cone

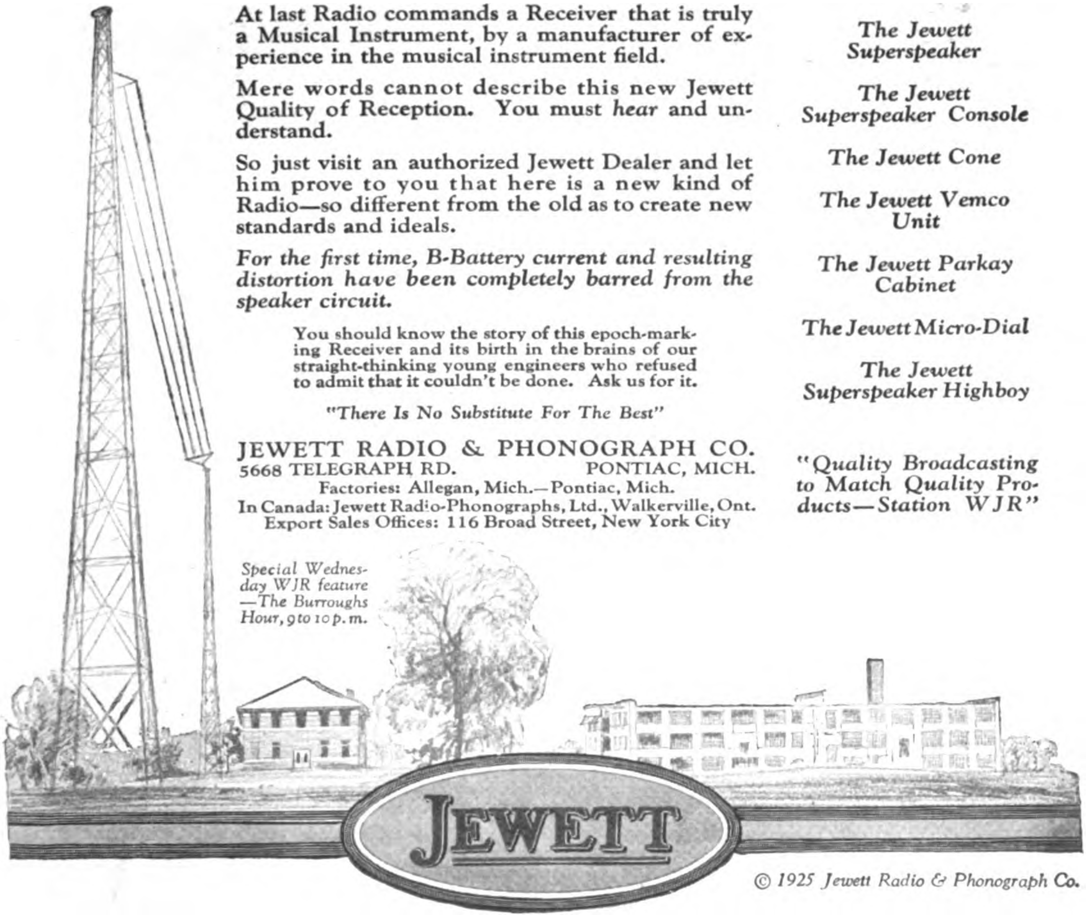
The Jewett Vemco Unit

The Jewett Parkay Cabinet

The Jewett Micro-Dial

The Jewett Superspeaker Highboy

"Quality Broadcasting to Match Quality Products—Station WJR"

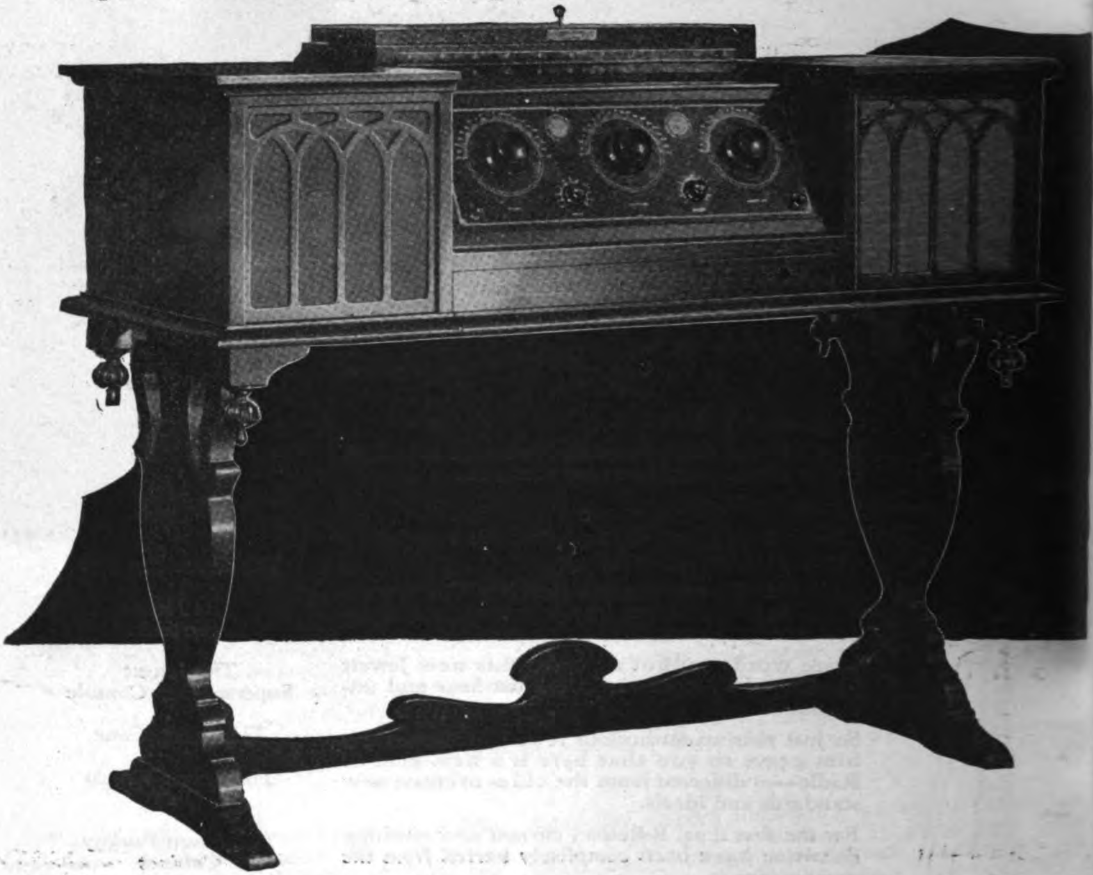


Special Wednesday WJR feature —The Burroughs Hour, 9 to 10 p. m.

© 1925 Jewett Radio & Phonograph Co.

Ozarka Senior Console—$197.50 East of Rockies

Complete with Tubes, Batteries and Speaker



"If Your Radio Is Bought Right It Will Be a Life-long Pal"

A LITTLE more time, a little more care in making the selection in the first place generally tends to more lasting satisfaction.

Out of every 100 Ozarkas sold in 1922 only eight are not today in the hands of the original owners—this does not include 17 out of each 100 who have purchased later Ozarka models in newer type cabinets. If there is a single Ozarka that is not in active service today, we have never heard of it.

Without the Ozarka Service in charge of direct factory trained representatives, such a record would not be possible. Ozarka service can be had today in almost every country. Purchasers in South Africa, Alaska, Sweden, Newfoundland, New Zealand, and Japan all receive the same practical service as those in Canada, United States, Mexico and Cuba. Whenever you find the sign of the Ozarka long distance

OZARKA

124 Austin Avenue C,
Chicago, Illinois

YOU'LL KNOW
THE MAN BY
THIS BUTTON

The Sweetest Story Ever Told
G.W.FRENCH

goose, you'll find a man who knows Ozarka instruments perfectly.

If such service added more to your cost price it might be a matter to consider, but it doesn't. Quality for quality, you'll find Ozarka prices lower—four tube Ozarkas with built-in loud speakers retail for $58.00—five tube with built-in speaker $64.00, up to solid walnut console design, $160.50.

Our nearest representative will gladly set up an Ozarka in your home, without any obligation whatever. He won't tell you what it will do—he will let you do all the tuning. With the Ozarka you must satisfy yourself as to distance, tone, volume, ease of tuning and selectivity.

More than this you will be very agreeably surprised at Ozarka prices—selling as we do, thru our own direct factory representatives, our selling expense is very low—we give Ozarka purchasers the benefit of it.

Where is there a value to compare with the one shown above—solid walnut cabinet (no walnut finish or veneer), imported English loud speaker of a marvelous tone, five tube instrument with 75 ampere Exide storage battery, 90 volts of Eveready "B" battery, 5 tubes, aerial equipment all erected and the price is only $197.50?

INCORPORATED

124 Austin Avenue C,
Chicago, Illinois

A Few More Men Are Needed to Sell Ozarka

In a great many counties we have the man we want. He is rapidly building up a permanent and profitable business of his own, because he has an instrument that will more than meet all competition. More than this, he is trained to back up his sales with the kind of service that counts.

Many well established Ozarka representatives started by giving us only their spare time—their evenings. If your county is open you can do the same.

The investment in cash is very small. The investment in time necessary for study is considerable. It requires patience, but the results have enabled many men to get out of the salary and time clock class.

Any previous sales experience is helpful but not necessary. We can and will teach you how to sell.

Send for 84-Page Book—"The Ozarka Plan"

This book is entirely too expensive to be sent out on postal card requests. It will be sent FREE to any man who mails the coupon below and who is really anxious to improve his condition. Tell us about yourself, ask for Ozarka Plan No. 100 and don't fail to give the name of your county.

Ozarka Incorporated
124 Austin Ave. C,
Chicago, Illinois

☐ Without obligation send book "Ozarka Instruments No. 200" and name of Ozarka Representative.

☐ I am greatly interested in the FREE book "The Ozarka Plan" whereby I can sell your radio instruments.

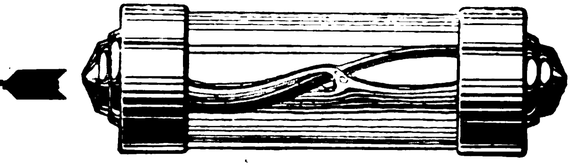
Name ....

Address .... City ....

County .... State ....

Introductory Offer

NONOISE VARIABLE GRID LEAKS



Range ½ to 7 Megohms **Price $.85**

Be Fair To Your Set **Put In The Best Grid Leak**

Wide range of resistance variation.
Noiseless operation.
Extremely low electrostatic capacity.
Ample room for adjustment without touching metal ends.
A size that fits all standard grid leak brackets.
Holds any adjustment given.
Used in any set it removes all doubt as to whether or not the grid leak resistance is correct.

Present this coupon to any Radio Dealer for

ONE NONOISE VARIABLE GRID LEAK

→FREE

RADIO FOUNDATION, Inc.

25 West Broadway **Dept. D49** **New York, N. Y.**

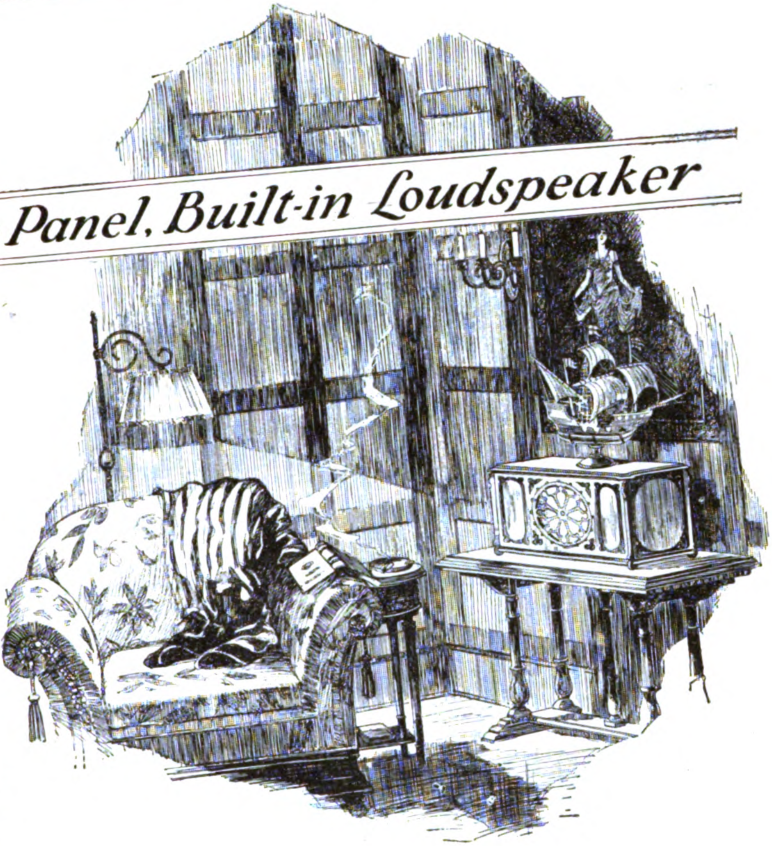
This offer good only until January 1st, 1926.
Ask any dealer to get it for you.
Dealers order from your Jobbers. Send this coupon along.
Jobbers order from US. Send this coupon along.

Each INTRODUCTORY OFFER COUPON must be accompanied by TEN CENTS for handling and shipping costs.

Your Name .... Dealer's Name ....

Address .... Address ....

No Dials, No Panel, Built-in Loudspeaker



Designed by R. E. Lacault, E.E., Chief Engineer of this company, and formerly Radio Research Engineer with the French Signal Corps Radio Research Laboratories.

Mr. Lacault's personal monogram seal (R.E.L.) is placed on the assembly lock bolts of all genuine ULTRADYNE Model L-3 Receivers. Guaranteed as long as these seals remain unbroken.

$135

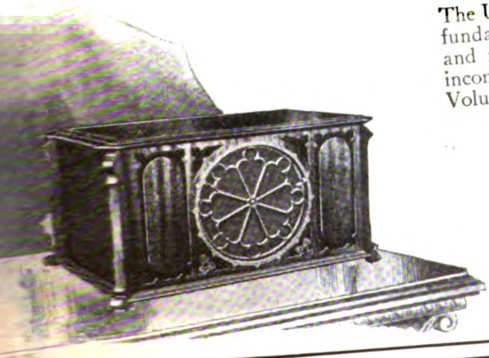
West of the Rockies $140.00

The Quiet Manner and The Eloquent Tone

A NEW artistic form of radio receiver is the Ultradyne Model L-3 Receiver. It blends happily with every scheme of interior decoration. Pleases the eye with its charming lines, its beautiful two-tone mahogany cabinet, its fine proportions. Has the appearance of a decorative tablepiece.

The Ultradyne Model L-3 is a six-tube receiver employing the fundamental principles of the best circuits, greatly refined and marvelously simplified. No dials—no panel; just two inconspicuous levers, which constitute a station selector. Volume adjustment is the only other control.

Write for handsome descriptive folder



ULTRADYNE

MODEL L-3

PHENIX RADIO CORP. 116 E. 25th St. New York

Take a Tip from KDKA

Pick a good,
stiff backbone
for your radio set—

MICARTA

REG. U. S. PAT. OFF.

RADIO PANELS

Like KDKA, the world's pioneer broadcasting station, Micarta *started something!* From a modest beginning in 1904, time and experience developed it into the finest kind of material for radio panels and tubing.

Drill or saw it. Micarta doesn't chip, check, crack or break-out. Be particular. Get the genuine article by asking specifically for Micarta.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY
Offices in All Principal Cities • *Representatives Everywhere*
Tune in with KDKA • KYW • WBZ • KFKX

Westinghouse

© 1925, W. E. & M. Co.

W
WESTINGHOUSE ELECTRIC

Westinghouse manufactures, also, a complete line of Micarta tubing, instruments and Rectigon Battery Chargers.

Micarta comes in four popular effects—mahogany, black, walnut grain and walnut burl—all with high gloss.

FABRICATORS OF MICARTA FOR THE RADIO TRADE

PAUL GOLDSTEIN & COMPANY, Inc., 54-56 Franklin Street, New York, N. Y.
CALVERT SPECIALTY COMPANY, 141 N. 11th Street, Philadelphia, Pa.

RADIO 'RITHMETIC

as an example

How *Near* are the *Far* Stations

That's an easy one. They're not far away at all; they're right with you, performing antics on your aerial, trying to make themselves heard.

Give them a real chance by keeping your batteries full of pep. That's another easy one! Just put the job up to a Westinghouse Rectigon.

It's for "A" batteries and "B" batteries; and your automobile battery will get a full kick out of this handsome little helper.

There's no muss or fuss when you use the Rectigon. No acids or chemicals. No moving parts and no noise! It's a high-quality Westinghouse Product throughout, guaranteed to make your storage-battery radio set satisfying and *complete.*

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, SOUTH BEND, INDIANA

The Westinghouse

© 1925, W. E. & M. Co.

Rectigon Battery Charger

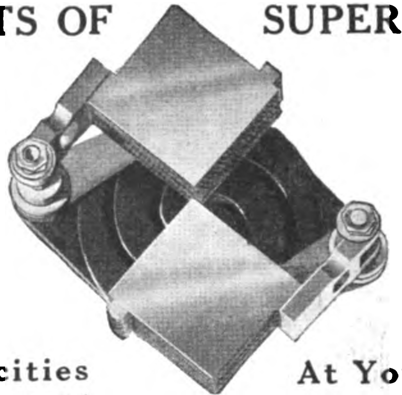
No storage-battery radio is complete without a Rectigon.

Westinghouse manufactures, also, a complete line of Micarta radio panels, Micarta tubes and instruments.

THE NEW SIGNAL
SPIRAL CAM CONDENSER*

Represents a radical departure in condenser design. The tuning efficiency is in the patented cam control

10 POINTS OF SUPERIORITY



This condenser utilizes the complete 360° of the dial.

Electrostatic field is concentrated in the center of condenser.

Dial shaft is dead—not connected to either set of plates.

Provided with pig-tail connections of tried-and-true efficiency.

All condensers have provisions for single or three hole mounting.

Unique construction eliminates all possibility of back lash.

Balanced condition of plate assemblies insures velvety action.

Die cast throughout insuring uniform characteristics in all units.

Compact being no larger than the old style semi-circular job.

Design permits direct mounting of air core transformers on condensers.

Three Capacities
.00025, .00035, .0005

At Your Dealer's
One Price - - $4.00

JOBBERS AND DEALERS:

If you are not fully acquainted with this popular condenser, ask us to send you complete information. Signal Radio Products are quality built—a good line to stock.

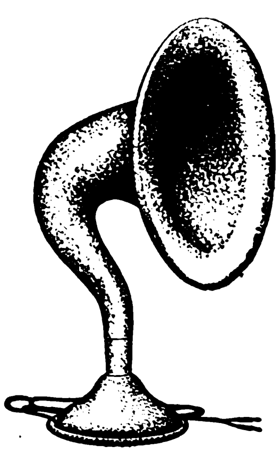
Signal Electric Manufacturing Co.
Dept. 10-L *Branches In All Principal Cities* **Menominee, Mich.**

**Tested and Approved by the* Popular Radio *Laboratories*

GENUINE BAKELITE
Radio Panels

We cut, drill and engrave for you Radio Panels of genuine Bakelite. ***Send rough sketch for estimate.*** A properly drilled and engraved panel ready for mounting is half the job of construction. Plain panels shipped C. O. D. same day order is received. Write for New Catalog on Radio Panels, Tubes and Rods—all of genuine Bakelite.

STARRETT MFG. CO.
522 S. GREEN ST., CHICAGO

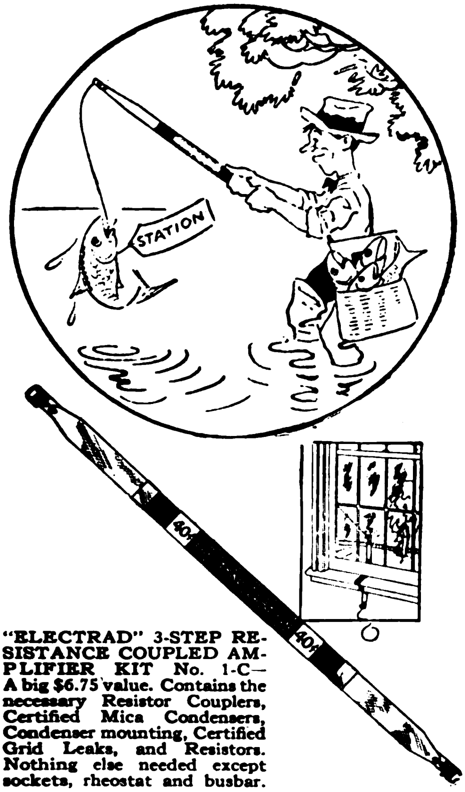


The KELLOGG Symphony Reproducer

All that the name implies in beauty of tone, volume and appearance. Priced at $25.00, and worth far more when the marvelous quality of the reception is compared with that of ordinary "loud speakers." Ask your dealer for a demonstration, or if your dealer does not carry it, write for folder 6-L.

Kellogg Switchboard & Supply Co.
1066 West Adams Street, Chicago

Helps to Land Everything You Catch



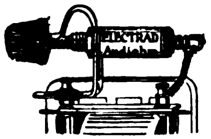
OUT of the air your antenna sifts tiny impulses—the makings of long distance reception. These faint bits of energy must be protected and brought undiminished to your receiver.

The "Electrad" Lead-in is a low-loss part which delivers these faint impulses to your set without waste.

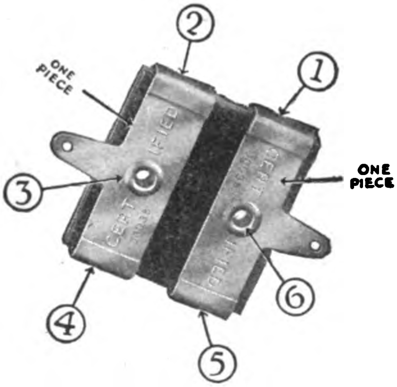
It's the most convenient form of lead-in. Now, you don't have to drill walls or sash. This flat, insulated and waterproofed lead-in fits under locked windows or doors. Meets the quality standard set by "Electrad." Get the genuine. There *is* a difference.

At your dealer's
Price 40c.

"ELECTRAD" 3-STEP RESISTANCE COUPLED AMPLIFIER KIT No. 1-C—A big $6.75 value. Contains the necessary Resistor Couplers, Certified Mica Condensers, Condenser mounting, Certified Grid Leaks, and Resistors. Nothing else needed except sockets, rheostat and busbar.



"ELECTRAD" AUDIOHM —Price $1.50—Eliminates distortion. Easily attached to secondary of first audio transformer. Once set it's permanent.



The "Electrad" Certified Fixed Mica Condenser is a revelation in accuracy and design. Ingenious, rigid binding and firm riveting fastens parts securely at Six different points insuring positive electrical contact. Value guaranteed to remain within 10% of calibration. Standard capacities, 3 types. Licensed under Pat. No .1,181,623, May 2, 1916, and applications pending. Price 30c to 75c in sealed dust and moisture proof packages.

"The Six Point
Pressure Condenser"

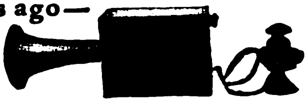
ELECTRAD INC.

428 BROADWAY NEW YORK CITY

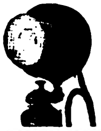
Also makers of other "Electrad" Radio Products—Variohms, Certified Grid Leaks, Lightning Arresters and Lamp Socket Antenna.

The Amplion Pedigree

Thirty-eight years ago—



In 1887 Mr. Alfred Graham invented and demonstrated the first practical loud speaker which the world had ever heard (illustrated above).



In 1893 Graham Loud Speakers placed upon market. Illustration shows the "1893 model."

In 1894 Graham Loud Speakers first used in British Navy. Graham transmitters applied to phonographs for loud speaker reproduction.

In 1896 Graham Loud Speaking Naval Telephones developed and adopted by British Admiralty.

In 1898 Graham Watertight Loud Speakers patented. Placed on many warships and mercantile vessels, throughout world.

In 1902 Complete Graham Loud Speaker installations, on central battery plan, erected on warships as sole means of communication.

In 1906 The most extensive loud speaking naval installation to date was made by Grahams. Included a Graham exchange system fitted to H. M. S. Dreadnought.

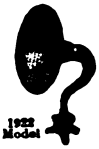
Onwards Graham Loud Speakers applied to all sorts and conditions of service at home and abroad, ashore and afloat.

By 1919 No less than 12,000 Graham loud speaking installations in operation on ships alone.

1920 Model

In 1920 (before radio loud speakers were in common use) "AMPLION" Loud Speakers produced for radio by Alfred Graham & Co. "AMPLION" trademark registered.

In 1922 Amplions adopted as standard equipment by leading makers of radio sets abroad.



1922 Model

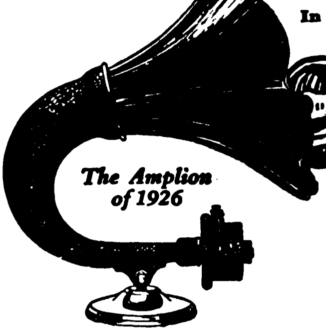
In 1923 Amplions introduced into United States, Canada and other countries. Quickly attained largest throughout-the-world sale of any loud speakers.

In 1924 To supply demand The Amplion Corporation of America was formed to market and manufacture Amplions here.

In 1925 More Amplion companies formed and agents appointed throughout world to keep pace with international demand. The Amplion Corporation of Canada, Limited, organized.

Created by the actual originators and world's oldest makers of loud speakers, it is only logical that the Amplion should be "the world's finest" radio reproducer. Some of the countries in which Amplions rule as favorites:

UNITED STATES
DOMINION OF CANADA
ENGLAND
SCOTLAND WALES
IRELAND
NORWAY SWEDEN
DENMARK
HOLLAND BELGIUM
FRANCE SPAIN
SWITZERLAND
ITALY JAPAN
SOUTH AFRICA
NEW ZEALAND
AUSTRALIA



The Amplion of 1926

To hear this new Amplion Dragon AR-19 is to appreciate why Amplions, year after year, internationally lead in sales. Six models, including phonograph units, $12 to $42.50. Write for interesting literature and dealer's address.

AMPLION

Alfred Graham & Co., London, England
Patentees

The World's Standard Loud Speaker

THE AMPLION CORPORATION OF AMERICA
Executive Offices: Suite X, 280 Madison Ave., New York City
Canadian Distributors: Burndept of Canada, Ltd., Toronto

Associated Companies and Agents: Alfred Graham & Co., London, England; The Amplion Corporation of Canada, Limited, Toronto; Compagnie Francaise Amplion, Paris, France; Compagnie Continentale Amplion, Brussels, Belgium; Amalgamated Wireless (Australasia), Ltd., Sydney and Melbourne; British General Electric Company, Ltd., Johannesburg and Branches; Indian States and Eastern Agency, Bombay and Calcutta; C. J. Christie E. Hijo, Buenos Ayres; David Wallace & Co., Valparaiso; Mestre & Blatge, Rio de Janeiro; F. W. Hammond & Company, London and Tokio.

Model A—
Price $175

You Might as Well Have the Perfect Receiver

WHEN you buy your Radio there are two things you will want to consider: "Am I getting the BEST Radio I can possibly get at the price," and "Is the Radio I am buying of an ADVANCED design that guarantees the PERMANENCY of my investment?" Buy a MU-RAD and you are absolutely assured of getting a satisfactory answer to both of these questions.

One big feature of the MU-RAD, alone, THE ONE DIAL CONTROL, is sufficient reason for you to decide on this great Radio Receiver. Think of being able to bring in any station at will, clear and strong, with the simple turning of one knob! The MU-RAD is calibrated in wave lengths to make logging of stations doubly easy.

MU-RAD is far in advance of the times. It is the Radio you will eventually buy if you want the Best—and the Best is always the cheapest in the long run.

Ask your dealer to show you the MU-RAD Transcontinental Receiver.

ONE DIAL CONTROL

MU-RAD

Transcontinental Receiver

5 Tubes
Sockets Fit
All New Tubes

Model B.

Price $125

MU-RAD RADIO CORPORATION

***Sales Office*, 972 BROAD ST., NEWARK, N. J.** ***Factory*, ASBURY PARK, N. J.**

Write Dept. F-4 for Literature

$25

West of Rockies, $26.50
In Canada, $35

The SAAL *Soft* SPEAKER

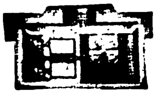
with the Bakelite Bell

SAAL Jr.

The same in every respect as the Saal Soft Speaker except it measures 18½ instead of 21½ inches in height.

$20

West of Rockies, $21
In Canada, $27.50



The Saal Soft Speaker Unit has no springs, no rubber gaskets, nothing to deteriorate. The diaphragm is connected to the armature by a pin, which pushes and pulls the diaphragm. The action is extremely precise, reproducing all consonants and overtones, yet the unit can't get out of order. This unit is used as standard in built-in reproducers by many leading radio manufacturers.

THE bell of the Saal Soft Speaker is of genuine Bakelite, the most perfect and resonant of all radio materials. The neck is of aluminum. There is no wood, no tin, no composition. The reproducing unit is of all-metal construction and cannot be harmed or "blasted" by the loudest receiver. It maintains its tone with any volume. There is no adjustment knob to complicate tuning.

When you buy the Saal Soft Speaker you buy once and for all. You buy a radio reproducer built to last a lifetime, one that will render permanent service and stand up under constant usage. It has nothing to deteriorate or wear out.

In buying the Saal you do not choose between volume and tone quality. It combines volume with a velvet tone. It is not a fad. It is not a trumpet. It is a faithful reproducer of radio programs, properly constructed and shaped for the accurate reproduction of sound. It removes the objection to loud speakers. It has no blare, no blast, no metallic ring.

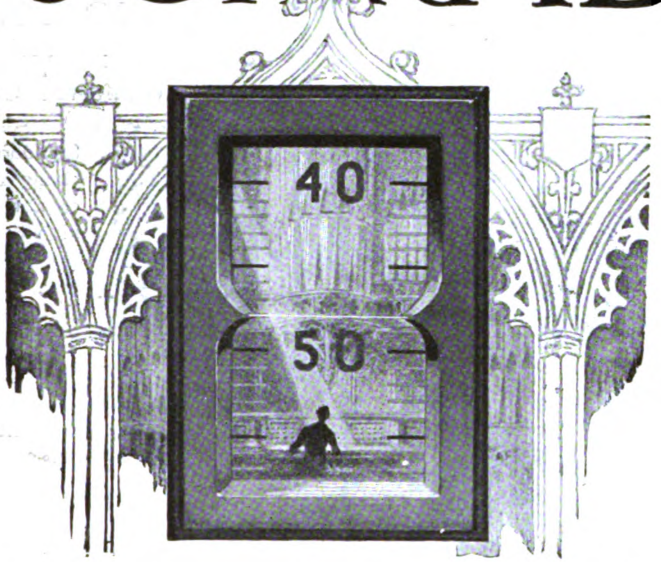
In appearance the Saal, with its black bell, black crackle throat and graceful lines is the aristocrat of horns. Also furnished with a brown bell and gold or silver stippled throat at $5 extra. It is guaranteed to give you satisfaction. Hear it at your dealer's today.

SAAL *Soft* SPEAKER

VOLUME WITH TONE QUALITY

Manufactured and guaranteed by H. G. SAAL COMPANY, 1800 Montrose Ave., Chicago, Ill.

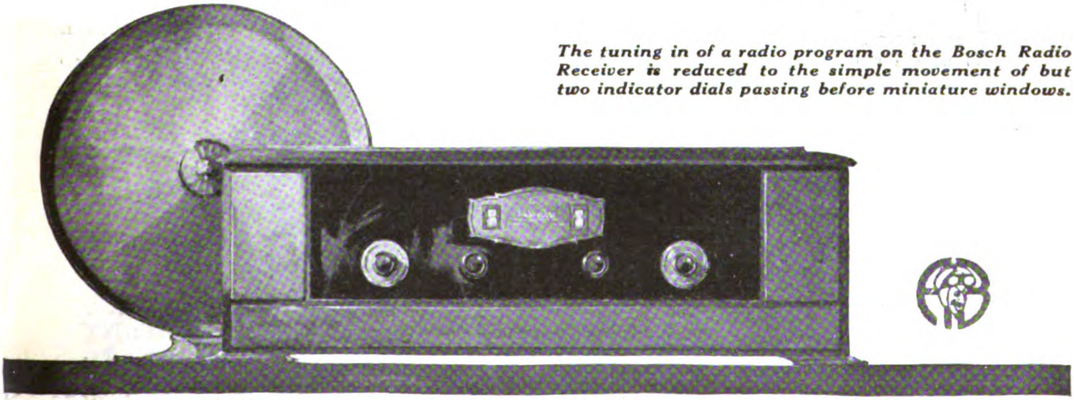
BOSCH RADIO



Windows of a New World

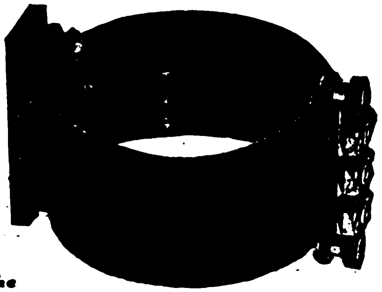
Through the windows of the Bosch Radio Receiver you bring into your home, the mighty swell of the pipe organ, the warmth of the voice, the soul of the violin or the stirring march of the band. A world such as you never knew before is yours. But a movement of your fingers and your favorite artist seems as if he were in the room. The simplicity of operation of the Bosch Radio Receiver, its unapproached tonal quality and its beauty of appearance has created a new appreciation of radio. . . . . Hear it.

AMERICAN BOSCH MAGNETO CORPORATION
Springfield Massachusetts

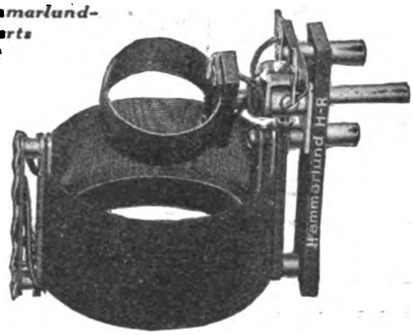


The tuning in of a radio program on the Bosch Radio Receiver is reduced to the simple movement of but two indicator dials passing before miniature windows.

and now —
HAMMARLUND *Low-Loss* COILS



The Hammarlund-Roberts Unit



AN efficiency obtainable almost exclusively in laboratory construction is now obtainable in a practical commercial form. By an ingenious process, Hammarlund engineers have devised a way to wind the famous solenoid coil with a definite space between turns, supported and anchored by a mere film of dielectric material. Thus, inductance is kept high, with low distributed capacity and absolutely no chance for short circuits.

They are regular equipment in the wonderful new Hammarlund-Roberts Receiver and the Eagle Neutrodyne. Various sizes and arrangements are available for other standard circuits.

Write for Folder

HAMMARLUND MFG. CO.
421-438 W. 33rd St., New York

For Better Radio
Hammarlund
PRECISION
PRODUCTS

BRACH

PUR-A-TONE AUDIO COUPLER

An Improved Resistance Coupler

Standardized, interchangeable for all stages, capable of withstanding high voltages. Pure-A-Tone is recognized by radio engineers of national repute who seek to attain maximum results.

BRACH-STAT Automatic Filament Controls eliminate need of hand rheostats on all amplified circuits.

At All Dealers

L. S. Brach Mfg. Co.

Newark, N. J.

Twenty Loose Connections in a Five Tube Set!

That's possible—but not if you use the new EBY Cushion Sockets.

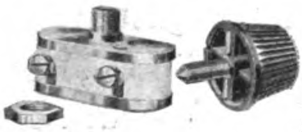
These ingenious devices make it possible to maintain a positive wiping contact at all times, regardless of the size of the tube prong or the amount of solder on the prong tip.

By a special shock-absorbing feature EBY Cushion Sockets not only eliminate microphonic noises but are a guarantee against tube damage.

Old style tubes will not give the advantages of interchangeability and other features of the new U. X. Tubes. EBY Cushion Sockets are especially built for them.

The list price for the EBY Cushion Socket is 60c. If your dealer can't supply you write direct to us sending his name.

H. H. EBY MFG. COMPANY
4710 Stenton Ave., Philadelphia, Pa.
***Makers of* EBY Quality Binding Posts**

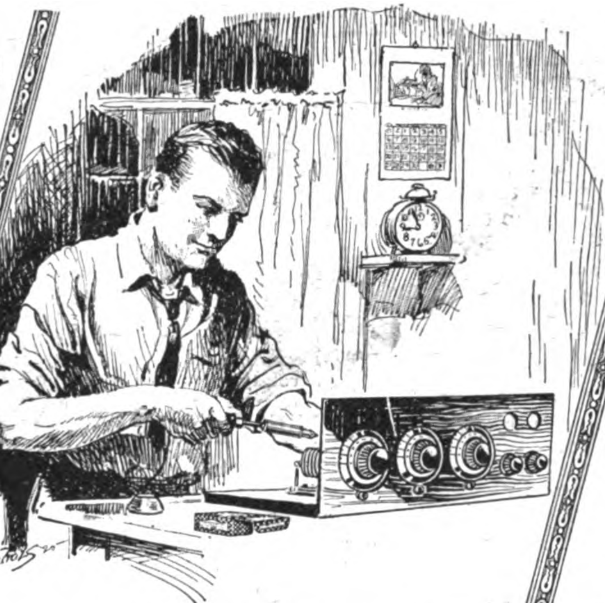


Bradleystat

Bradleyleak

Bradleyometer

Bradley-switch



Bradley-nier

Bradleyunit

Bradleyohm

For Genuine Satisfaction Use Allen-Bradley Parts

RADIO SETS, like all electrical devices, are no better than the parts used in their construction. The experienced set builder has discovered the futility of using poorly made, inefficient units in his set.

Allen-Bradley Perfect Radio Devices are so carefully made and so beautifully finished that they assure perfection in performance and appearance. In fact, the noiseless, perfect control of Allen-Bradley radio devices has never been surpassed and many of the finest factory built sets today are equipped with Allen-Bradley parts.

Ask your dealer for Allen-Bradley perfect radio devices when you build your next set. If you are not acquainted with the entire Allen-Bradley line mail the attached coupon today for our latest illustrated literature.

Allen-Bradley Co.
Electric Controlling Apparatus
276 Greenfield Ave.
Milwaukee, Wis.

Manufacturers of Graphite Disc Rheostats for Over 20 Years

ALLEN-BRADLEY CO.,
276 Greenfield Ave.,
Milwaukee, Wisconsin

Please send me, by return mail, your latest illustrated literature of the complete Allen-Bradley Line.

Name ....

Address ....

LC-26

The 1926 Circuit Is Here!

Laurence M. Cockaday has secured a triumph with his new four-circuit tuner. New in design and construction, the operating efficiency and simplicity of the LC-26 will appeal to thousands who built the original four-circuit tuner.

COCKADAY LC-26

1	General Radio Type 269 Variometer with Knob	$5.30
1	General Radio Rheostat Type 214-A, 7 Ohms	2.25
1	Precision Octoform Coil Set	5.50
1	Amsco Double Condenser No. 1814	6.25
1	Micamold Condenser .00015 mfd.	.35
1	Micamold Condenser .00025 mfd.	.35
2	Daven Resisto Couplers with .1 mfd condensers	3.00
1	Amertran De Luxe 1st Stage Transformer	10.00
1	Bradleyleak ¼ to 10 megs	1.85
3	Bradleyunits ¼ meg.	2.25
1	Bradleyunit ½ meg.	.75
3	Amperites No. 1A	3.30
1	Amperite No. 112	1.10
8	Benjamin Standard Sockets	5.00
1	Carter Single Circuit Jack	.70
2	Carter No. 2 Jack Switches	2.00
8	Eby Binding Posts	1.20
1	Fynur Vernier Dial	3.50
1	Drilled and Engraved Panel	7.50
1	Cabinet, Mahogany or Walnut Finish	14.50
1	Hardwood Baseboard	.50
4	Small Brass Brackets	.20
2	Large Brass Brackets	.15
1	Antenna Connection Block, 1 by 2 inches	.15
1	Battery Connection Block, 1 by 6 inches	.25
		$77.90
	Blueprints for LC-26	$1.00

Simplicity in tuning, radio frequency amplification, and tonal quality that is a revelation of accuracy are all in this new set.

Leading radio experts have already placed their seal of approval on the LC-26.

Morison's has all the parts used by Mr. Cockaday, ready for you NOW!

Mail Orders Filled Promptly.

WHOLESALE RETAIL

MORISON Electrical Supply Co. Inc.

15 East 40th Street, New York City

McLaughlin Parts—Exactly as Specified Are Here for the Fan.

An eight tube one control set which you can easily build.

Blueprints that are full size and complete make the assembly the easy work of a few hours.

COMPLETE PARTS

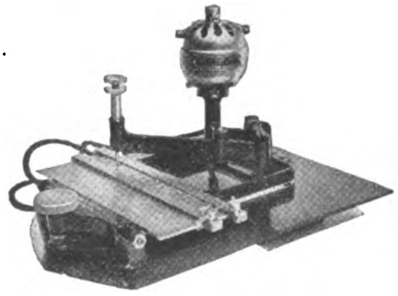
$113.30

A postcard will bring the list of parts and full information on this or any other circuit in which you are interested.

AT LAST!

A Real Panel Engraving Machine at a Price you can afford

Low in price because it is designed for panel engraving only



For engraving your own panels, or panels for others with any marking desired, including Trademarks, special designs and serial numbers.

Being designed particularly for panel engraving, it is the most rapid and accurate machine for engraving panels. Simple to operate. 14 x 40″.

Price of Machine with full equipment, including master letters and characters, $135.00 f.o.b. Forestdale, R. I.

Wire or Write

BRANCH TOOL CO. **Dept. O, Forestdale, R. I.**

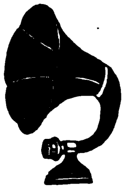
Burns SPEAKER

WITH

CONCERT UNIT

The Heart of the Speaker

Large size and scientific construction of the Concert Unit gives the remarkable tone values which, combined with the special amplifying properties of the BURNS horn, produce wonderful results.



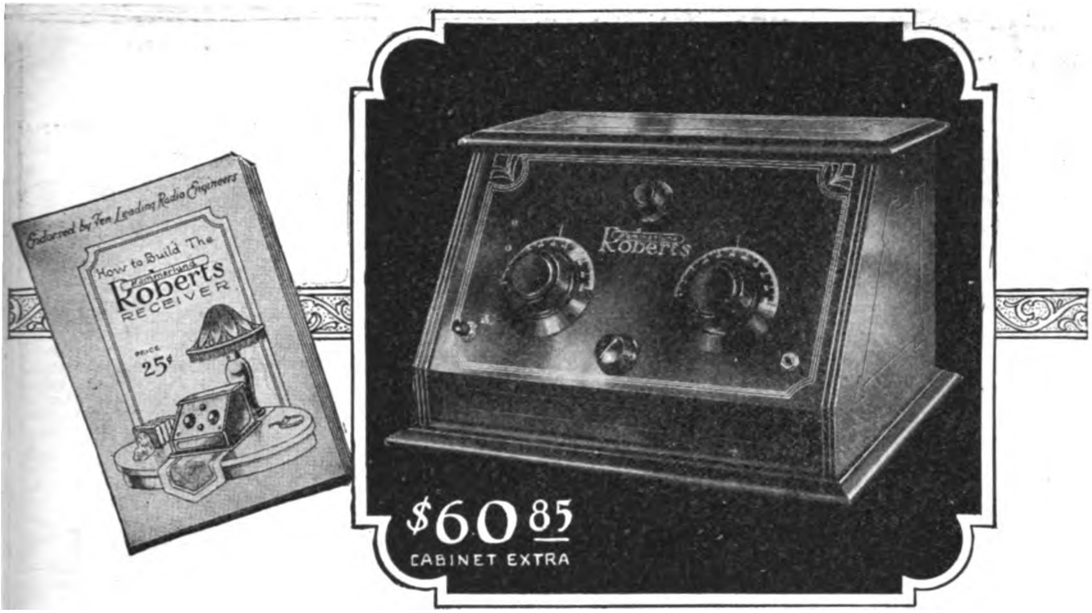
BURNS horn is of distinctive design with pyralin flare in several handsome finishes.

Prices — $22.50 — $25.00 — $30.00

Manufacturers

American Electric Company

State and 64th Streets
CHICAGO, U. S. A.


Endorsed by Ten Leading Radio Engineers
How to Build The Hammarlund Roberts Receiver
Price 25¢
Hammarlund Roberts
$60 85
CABINET EXTRA

WRITE FOR THIS BOOK

You will find it surprisingly easy to build the Hammarlund-Roberts Receiver from this instruction book. Fully illustrated throughout. **25c**

Associate Manufacturers

- All-American Radio Corporation
- Alden Manufacturing Co.
- Radiall Company ("*Amperites*")
- Carter Radio Co.
- Union Radio Corporation
- International Resistance Co., Inc. ("*Durham Resistors*")
- Westinghouse Micarta
- Hammarlund Mfg. Co., Inc.

Every Part Designed by a Specialist

EVERY single unit that goes to make up this remarkable receiver was chosen by a specialist after months of research. The transformers were selected by an engineer familiar with every reliable make; the condensers by a man who had made a special study of condenser constructions and functions. So it was even with the smallest, usually neglected units.

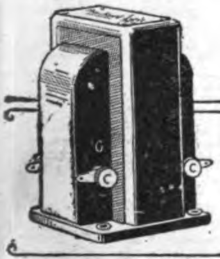
From the work of these engineer-designers, backed by the endorsements of ten famous radio parts manufacturers, comes the Hammarlund-Roberts, a receiver that is truly the ultimate in five-tube possibilities. The equal of any standard eight-tube set in selectivity and volume,—so simple in design and operation that anyone might construct it. Priced amazingly low, the Hammarlund-Roberts offers the greatest value possible in the radio field to-day.

Rauland-Lyric
AN
ALL-AMERICAN
TRADE MARK
TRANSFORMER

This instrument and other parts shown are some of the famous units used in the Hammarlund-Roberts.

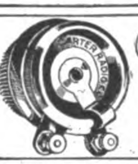
Hammarlund Roberts

Hammarlund-Roberts 1182 Broadway New York, N.Y.



NA-ALD

Dials and Sockets



Carter

Switchboards and Rheostats

UNION

Phone Tip Jack

DURHAM

Resistor

Takes the MYSTERY out of RADIO!

100,000 SOLD
514 PAGES

Compiled by
HARRY F. DART, E.E.
Formerly with the Western Electric Co., and U. S. Army Instructor of Radio. ***Technically edited by***
F. H. DOANE.

BE A RADIO expert—it's easy for the 100,000 who own this compact, complete Radio Handbook. Written in good, plain, understandable language. Crammed full of facts, every one useful and important. Explains how receivers and transmitters work, how to build and operate them. Whatever you or your friends want to know, it's here. Will save you many times its small cost.

TELLS ALL ABOUT: Electrical terms and circuits, antennas, batteries, generators and motors, electron (vacuum) tubes, most receiving hook-ups, radio and audio frequency amplification, broadcast and commercial transmitters and receiving, super-regeneration, codes, license rules. Many other features.

Nothing else like it. Make this extraordinary book your radio library—just this one little giant is all you need. Everything in one index, under one cover, in one book, for one dollar. The biggest dollar's worth in radio today. Combines the knowledge of many expensive works. Buy this and save the difference.

Just mail the coupon with a dollar bill and your name and address, and this 514-page I. C. S. Radio Handbook will be sent to you by return mail. Note the other good books listed below at low prices.

INTERNATIONAL CORRESPONDENCE SCHOOLS
Box 8254-F, Scranton, Penna.

I enclose $........, for which send me, post-paid, the Handbooks marked X, at $1 each. It is understood that if I am not entirely satisfied I may return them within five days and you will refund my money.

☐ RADIO HANDBOOK, 514 PAGES, $1

☐ Automobile Handbook, 354 pages - - - - - -	$1
☐ Electrical Handbook, 414 pages - - - - - -	$1
☐ Chemistry Handbook, 348 pages - - - - - -	$1
☐ Pharmacy Handbook, 324 pages - - - - - -	$1
☐ Traffic Handbook, 386 pages - - - - - - -	$1
☐ Building Trades Handbook, 409 pages - - - -	$1
☐ Machine Shop Handbook, 335 pages - - - - -	$1
☐ Salesman's Handbook, 352 pages - - - - - -	$1
☐ Advertising Handbook, 445 pages - - - - - -	$1
☐ Bookkeeper's Handbook, 302 pages - - - - -	$1
☐ Civil Engineer's Handbook, 411 pages - - - -	$1
☐ Steam Engineer's Handbook, 298 pages - - - -	$1

Name..

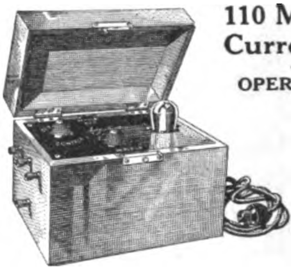
Address..

Enclose $1.50 instead of $1 for each book if you want the Leatheroid binding. All of the above books can be had in this binding except the Traffic Handbook and the Building Trades Handbook.

New and Improved

Mayolian "B" SUPPLY

"The 'B' Without a Buzz"



110 Milliamperes Current Output

OPERATES ANY SET

Consumes very little current and is stable and uniform in operation. Amplifier voltage variable from 90 to 200 volts; detector voltage from 0 to 65 volts. Equipped with a

Raytheon Rectifying Tube

the life and efficiency of which is practically unlimited. Encased in a compact and attractive cabinet. Absolutely Guaranteed.

Type 606—Alternating Current, 110 Volts, 60 Cycles. Price (including tube) $47.50	Type 607—Direct Current, 110 Volts. Price, complete $25.00

If your dealer cannot supply you, send money order, and we will ship direct.
Regular discounts to Jobbers and Dealers.

Mayolian Radio Corp.
1991 Broadway **New York City**
N. Y. Distributor—20th Century Radio Corp.
102 Flatbush Av., B'klyn, N. Y.

$3.25 C.O.D.

RADIO Storage "B" Battery

12 Cells
24 Volts

Lasts Indefinitely—Pays for Itself

Economy and performance unheard of before. Recharged at a negligible cost. Approved and listed as Standard by leading Radio Authorities, including Pop. Radio Laboratories, Pop. Sci. Inst. Standards, Radio News Lab., Lefax, Inc., and other important institutions. Equipped with *Solid Rubber Case,* an insurance against acid and leakage. Extra heavy glass jars. Heavy, rugged plates. Order yours today!

SEND NO MONEY **Just state number of batteries wanted and we will ship day order is received. Extra Offer: 4 batteries in series (96 volts), $12.75. Pay expressman after examining batteries. 5 per cent discount for cash with order. Mail your order now!**

WORLD BATTERY COMPANY
1219 So. Wabash Ave., Dept. 77 Chicago, Ill.
Makers of the famous World Radio "A" Storage Battery
Prices: 6-volt, 100 Amp. $11.25; 120 Amp. $13.25; 140 Amp. $14.00
All equipped with Solid Rubber Case.

World
STORAGE BATTERIES

Set your Radio Dials at 210 meters for the new 1000 watt World Storage Battery Station, WSBC, Chicago. Watch for announcements.

Simplify and improve radio reception with Balkite Radio Power Units

FOR THE **A** CIRCUIT

Balkite
Battery Charger

This popular battery charger is entirely noiseless and can be used while the radio set is in operation. Charging rate 2.5 amperes. Operates from 110-120 AC 60 cycle current. Special model for 50 cycles. Also for 25-40 cycles with 1.5 ampere charging rate.

Price $19.50
West of Rockies, $20
In Canada, $27.50

Balkite
Trickle Charger

Charges both 4 and 6 volt radio "A" batteries. Will furnish more current than is used for 6 dry cell or 2 storage battery tubes, if used only while the set is in operation. If allowed to "trickle" charge continuously will also furnish enough current for as many as 8 dry cell or storage battery tubes. Size 5¾ in. long, 2¾ in. wide, 5 in. high. Operates from 110-120 AC 60 cycle current. Special model for 50 cycles. *Price $10*
West of Rockies, $10.50
In Canada, $15

Balkite Radio Power Units simplify and improve radio reception. They reduce the amount of attention you must give your set. With their use your current supply is always exactly what is required for each circuit.

For the "A" circuit there are the Balkite Chargers. The popular Balkite Battery Charger can be used while the set is in operation. For sets of smaller "A" current requirements—there is the Balkite Trickle Charger. With a low capacity storage battery it enables owners of sets now using dry cells to make a most economical installation. For the "B" circuit there is Balkite "B." It eliminates "B" batteries entirely and supplies plate current from the light socket. Specially designed to serve sets of 6 tubes or less. For sets of 6 tubes or more there is Balkite "B" II.

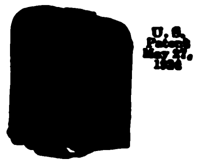
Noiseless—No bulbs—Permanent

All Balkite Radio Power Units are entirely noiseless in operation. They have no moving parts, no bulbs, and nothing to adjust, break or get out of order. Each is a permanent piece of equipment with nothing to wear out or replace. They require no other attention than the infrequent addition of water. They require no changes or additions to your set.

Manufactured by
FANSTEEL PRODUCTS COMPANY, Inc.
North Chicago, Illinois

FANSTEEL
Balkite
Radio Power Units

FOR THE **B** CIRCUIT

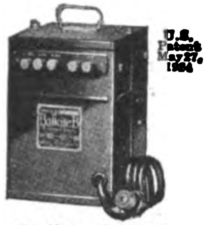


Balkite "B"

Eliminates "B" batteries. Supplies plate current from the light socket. Operates with either storage battery or dry cell tubes. Keeps "B" circuit always operating at maximum efficiency. Requires no attention other than adding water twice a year.

Will serve any set requiring not more than 20 milliamperes at 90 volts —practically all sets of 5 tubes or less, and most 6 tube sets. Occupies about same space as 45 volt dry "B" battery. Operates from 110-120 AC 60 cycle current. Special model for 50 cycles.

Price $35
In Canada, $49.50



Balkite "B" II

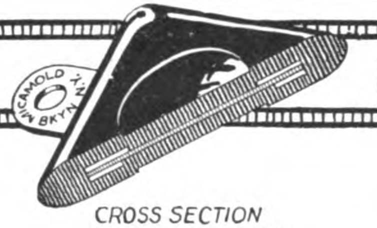
Same as the new Balkite "B" but will fit any set including those of 8 tubes or more. Operates from 110-120 AC 60 cycle current. Special model for 50 cycles.

Price $55
In Canada, $75

The Gould Unipower is equipped with a special Balkite Radio Power Unit

BALKITE BATTERY CHARGER · BALKITE TRICKLE CHARGER · BALKITE "B" · BALKITE "B" II

ALL BALKITE RADIO POWER UNITS ARE TESTED AND LISTED AS STANDARD BY THE UNDERWRITERS' LABORATORIES



MADE OF MICA AND MOULDED IN BAKELITE

CROSS SECTION
SHOWING INTERNAL
CONSTRUCTION

Micamold
REG.
FIXED CONDENSERS

LC-26
BROADCAST RECEIVER

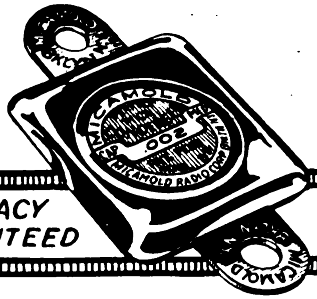
Micamold Products are used in the LC-26 Broadcast Receiver.

Radio engineers and manufacturers everywhere have adopted these products as standard—they always satisfy.

The crowning achievement of Condenser manufacture—Internal construction of the best India Mica and Tin Foil moulded in genuine Bakelite to withstand heat and cold, thus moisture proof and noiseless. Guaranteed within 5% of calibration and constant in value. Write for descriptive circular.

Sold at all good Radio Stores

MICAMOLD RADIO CORPORATION
Flushing and Porters Avenues, Brooklyn, N. Y.



ACCURACY GUARANTEED

VALUES REMAIN CONSTANT

MOULDED UNDER PRESSURE OF 50 TONS

50 TONS

COCKADAY LC-26

The "Universal Decorated" Panel

Hit of the Radio Show

A Bakelite panel in black and gold as pretty as a picture.

Decorated, drilled and completed especially for the Cockaday LC-26 Set

Universal Insulation Co.
215 Emmet St. Newark, N. J.

DO IT YOURSELF
—It's Easy

Manufacturers FLASH tubes during the process of building them. In doing so, they boil out the thorium with which the filament is impregnated and deposit it on the surface, permitting the filament to function at low heat.

As the tube is used in the set, the thorium coating gradually disappears. FLASHING will boil out some more thorium to the surface of the filament and bring the tube back as good as new.

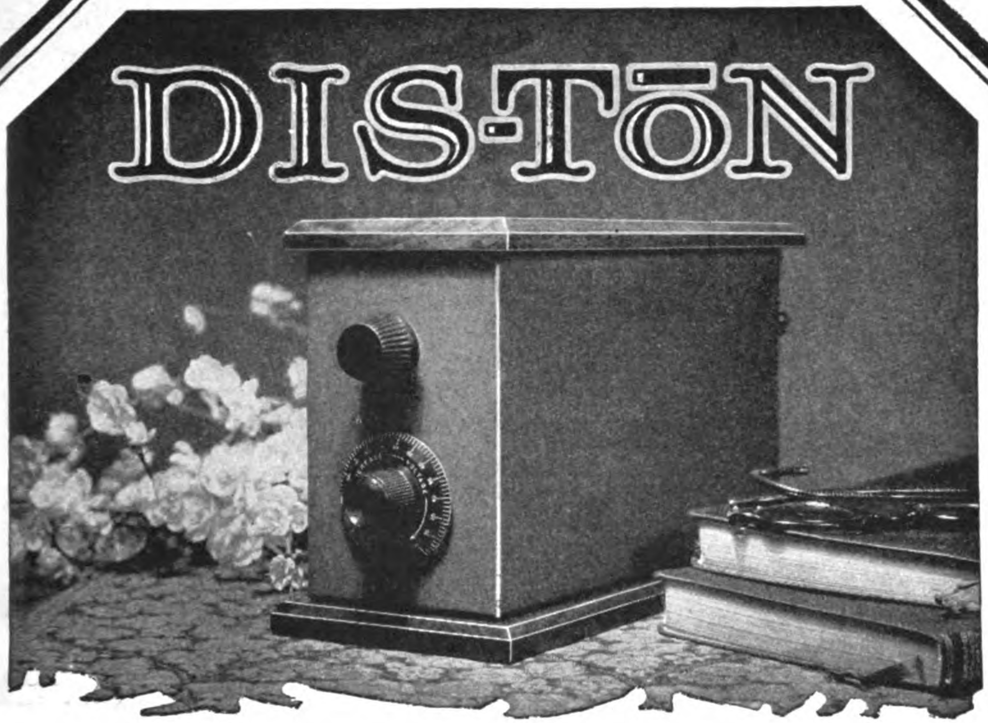
YOU CAN DO IT YOURSELF WITH A

BURTON & ROGERS TUBE FLASHER

$7.50

Send for pamphlet "Save a Life"

BURTON & ROGERS MFG. CO.
755 BOYLSTON ST., BOSTON, MASS.



Dis-ton uses no fluids. Requires no attention in or out of operation. Handsomely finished and sealed against deterioration. Consumes only eight watts.

Uses House Lighting Alternating Current in place of "B" Batteries

Obviate the need of constant care or expensive replacement and get the maximum performance possible from your receiver. No need to handicap your reception by a dwindling "B" current when you can throw the load on the big, powerful, carefully tended generators of your central station.

Amazing Tone Quality—Selectivity—Volume

Distance too! Because Dis-ton provides exactly the right potential suited to your circuit, tubes and loud speaker. "B" Current from Dis-ton is free from hums, current noises, pops and crackles. It insures you the equivalent of a new "B" Battery every time you listen in. Dis-ton is dependable—always!

DIS-TON
110 volt, 60 cycle
complete
$40.00
Other voltages and cycles on application

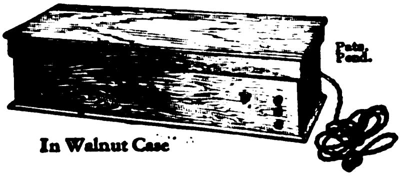
Know Dis-ton Advantages on Your Own Set

Dis-ton performance is outstanding. In every locality it is making radio reception more consistent, satisfactory and trouble free. Send for details of Dis-ton demonstration whereby you are the judge without obligation.

DIS-TON KIT
for Set Builders
110 volt, 60 cycle
$28.50
Other voltages and cycles on application

RADIO PRODUCTS, Inc.
Dept. PR RICHMOND, IND.

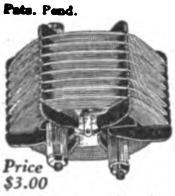
The Wilson "B"
Radiopower-Unit



This new unit makes it possible to use a light socket for "B" voltage, *without any troublesome hum from alternating current.*

Supplies the constant voltage necessary for perfect reception. No acid to spill. No moving parts. Requires no attention. Semi-automatic in operation. The least expensive type of unit because of low first cost, minimum current consumption and long life. *In handsome walnut case. Price $35.*

The Andrews
Paddlewheel-Coil



Price $3.00

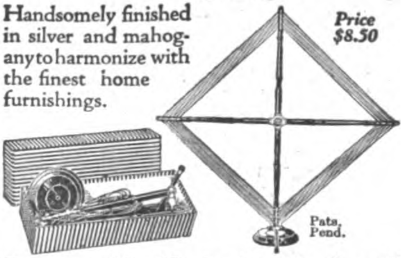
For best results in home-built sets it is safer to use equipment employed in the best commercial receivers. Here is a superior coil used in such high grade receivers as the *Deresnadyne* and *Buckingham*. It can be used in any hook-up requiring a high type inductance.

Has exceptionally high ratio of inductance to resistance with minimum distributed capacity. Improves tone. Increases range, volume and selectivity. Blue prints of tested hook-ups employing this coil are available.

Our Technical Dept. will answer inquiries.

Duo-Spiral
Folding Loop

Handsomely finished in silver and mahogany to harmonize with the finest home furnishings.



Price $8.50

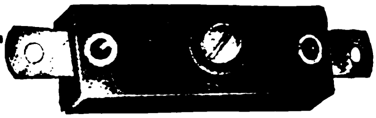
Easily portable. Has insulated handle and graduated dial. Reduces static and other interference. A special model for every circuit.

See these standard units at your dealers or write for complete information.

Radio Units Inc.

1301 FIRST AVE., MAYWOOD, ILL.
Perkins Elect. Ltd., Montreal, Toronto, Winnipeg

DON'T WAIT!



PEP UP THAT SET NOW WITH

X - L RADIO PRODUCTS

Just install them in your receiver and hear them speak for themselves

***Endorsed by* LAURENCE M. COCKADAY and other leading radio authorities in all the latest circuits**

Model "N" Vario Denser

Capacity range 1.8 to 20 micro-micro-farads, for balance in Roberts two tube, Browning-Drake, McMurdo Silver's Knockout, Neutrodyne and tuned radio frequency circuits. Price $1.00

Model "G" Vario Denser

Two capacity ranges, .00016 to .00055 and .0003 to .001 Microfarads, for the Cockaday circuits, filter and intermediate frequency tuning in super-heterodyne and positive grid bias in all sets with grid-leak clips. Price $1.50

X-L Push Post

A binding post that really does excel in looks, action, service and convenience. Just push it down— insert wire—cannot jar loose from vibration. No screwing or danger of shearing off wires. Furnished attractively plated with soldering lug and necessary markings.

Price Each 15 Cents

X-L RADIO LABORATORIES
2422 Lincoln Ave. CHICAGO

DisXron $1.75
The Pep Tube
AT DEALERS OR BY MAIL
TYPE 201-A
DisXron
JUSTRITE SALES CO. NEWARK N.J.

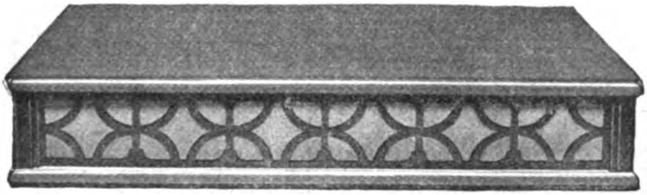
DisXron Tubes are noted for their "Pep." They will make that set of yours shout with joy! The tone is brilliant and clear. They "eat up" DX, too!

All standard types. Every tube tipless, mounted on a base of *pure* BAKELITE and GUARANTEED to give absolute satisfaction.

Order from your dealer, or direct by mail, C.O.D. or prepaid by Money Order. All types, $1.75 each. WE PAY POSTAGE.

Dealers: Write Now!

JUSTRITE SALES CO.
230 Market Street, Dept. 200, Newark, N. J.



CHRISTMAS:
and thoughts of Presents

What could please the whole family better than a Radio Set and of course a real good speaker ?

May we suggest the New **TIMBRETONE** REG. U.S. PAT OFF on the following points ?

1. It is small—18¾ inches long, 10¼ inches wide, 4 inches high.
2. All wood—meaning excellent tone quality.
3. Beautiful mahogany DUCO finish.
5. Reproduces over a wider tone scale than the ordinary speaker.
6. Volume and Quality—in one unit.
7. It has a non-metallic diaphragm—"no tinny sounds."
8. It is a musical instrument and should be treated as such.

Just a REAL GOOD SPEAKER
at 30^{00}

For Sale Through

SANFORD BROTHERS

Chicago, Ill.
30 W. Walton Place

Chattanooga, Tenn.
615 Broad St.

Seattle, Wash.
Am. Bank Bldg.

San Francisco, Cal.
311 Minna St.

FACTORY:

TIMBRETONE MFG. CO.
Hoosick Falls, N. Y.

This Nagel Voltammeter is the ideal instrument for testing A and B dry batteries. If you are operating your set with dry cells, or own a Super-Het, you'll appreciate this two-in-one instrument.

Popular!

—because accurate and safe

Radio has reached the stage where the public demands quality of tone rather than quantity. The operation and maintenance of your set may be impaired by the purchase and use of a cheap, low-resistance voltmeter. Nagel voltmeters are built to a standard for high resistance—60 Ohms per volt—giving accurate readings under any climatic conditions and protecting the batteries against drainage, whether tested by intermittent touch or continuous contact. If your dealer hasn't a supply of Nagel instruments, write The W. G. Nagel Electric Company, 513 Hamilton Street, Toledo, Ohio.

NAGEL

Manufacturers of
DRY CELL TESTERS · AMMETERS
HIGH-RESISTANCE VOLTMETERS
and VOLTAMMETERS · BAKELITE
HOT MOULDED INSULATIONS

CARTER

New "Flat" Plug

(Pat. Pend.)

Full Size **75c**

New original Carter design. Fits flush against panel. Cord hangs down. Cord tips quickly and easily attached or detached. No push buttons, trick triggers or springs. Positive, simple. Improves appearance of any set.

MEMBER RMA ***Any dealer can supply***

In Canada—Carter Radio Co., Limited, Toronto

Carter Radio Co.
300 S. RACINE AVE.
CHICAGO, ILL. U.S.A.

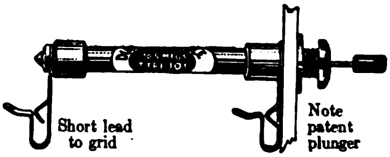
DURHAM

Variable Leaks

Make Good Tubes Better

Standard Type

For any set. Snap in place of present fixed leaks. Adjustable in line with tube makers instructions. **75c**



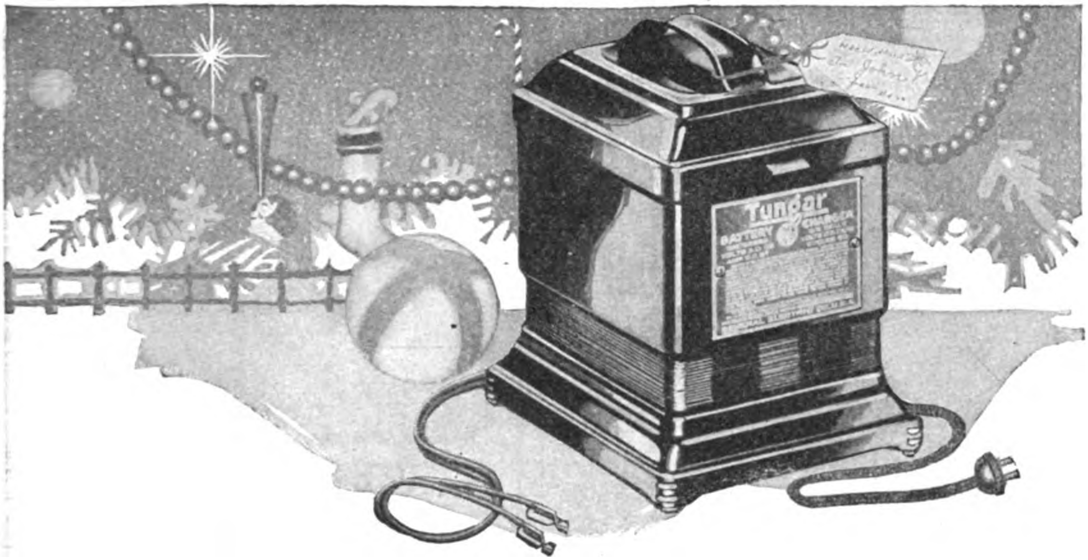
***New* Panel Mount**

Accurate control of detector or audio at your finger tips brings better results. **$1**

There's a DURHAM for every need

No. 100—1,000 to 100,000 ohms (audio)
No. 101—0.1 to 5 megohms (for UV-200 and WD-12)
No. 201A to 5 megohms (for UV-199 or 201A tubes)

DURHAM & CO., Inc.
1936 Market St., Philadelphia



What to give the radio fan

Give him a two-ampere Tungar if he has a storage battery *of any kind.* It will charge all his radio batteries and his auto battery, too.

Or, for bigger jobs, give him a five-ampere Tungar—built to do the same work but to do it more than twice as fast.

Every man who has a storage battery wants a charger. And every man who wants a charger wants the original General Electric bulb charger—the Tungar.

The Tungar is a G-E product, developed in the Research Laboratories of General Electric.

The new Tungar charges any make and size of storage battery: radio "A" and auto batteries, and "B" batteries as high as 96 volts in series.

Prices

Two ampere size	**$18.00**
Five ampere size	**$28.00**
60 cycles . .	***110 volts***

Tungar

REG. U.S. PAT. OFF.

BATTERY CHARGER

Tungar—a registered trademark—is found only on the genuine. Look for it on the name plate.

Merchandise Division
General Electric Company, Bridgeport, Conn.

GENERAL ELECTRIC

The Loud Speaker Sensation...!

$15.00

Design Patented

The KODEL MICROPHONE LOUD SPEAKER

An exact replica of the transmitting microphone used in broadcasting stations.

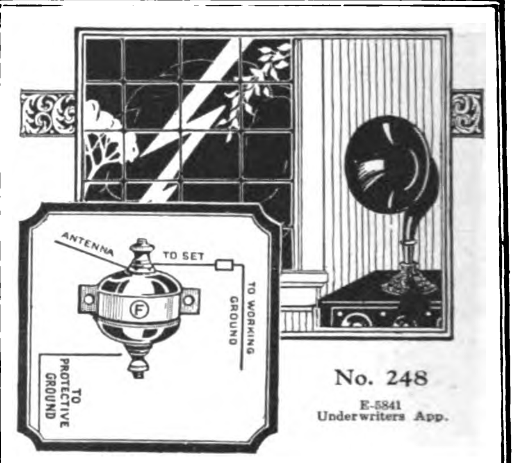
The efficient KODEL SOUND UNIT, with an ingenious new snail-shell horn, mounted inside the microphone case, produces a remarkably clear, full-toned volume, with every note as rich and true as when it enters the transmitting microphone in the studio. Non-vibrating tone chamber absolutely eliminates distortion.

With Kodel, Jr. unit, $15; with large Kodel unit, $20; Radio dealers everywhere have them.

THE KODEL RADIO CORP.
504 E. Pearl St. Cincinnati, O.

Manufacturers of Kodel Radio
Receivers and Accessories, and
Homcharger Battery Chargers.

WKRC
Owners of Kodel Broadcasting
Station WKRC. Send for program



"Little Joe"
Lightning Arrester

Especially designed for Radio Work. Made of Porcelain, small, neat, rugged and serviceable. Can be suspended on antenna or fastened to wall.

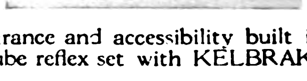
Ask Your Dealer

M'f'd by CIRCLE F MFG. CO.
Trenton, New Jersey

The New Universal

KELBRAKET

"Makes Set Building Straight Sailing"



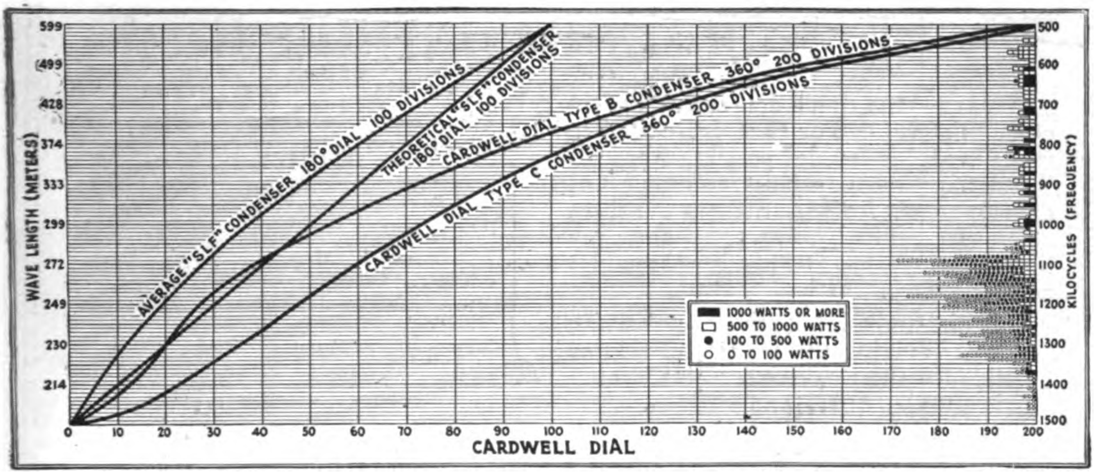
Appearance and accessibility built into a two-tube reflex set with KELBRAKETS.

Clean-cut aluminum Kelbrakets, weighing only 4 ounces, hold main and sub panels rigid and supplant the old "plank."

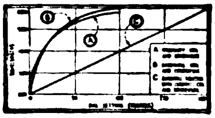
KELBRAKET No. 15 (per pair) ...	**$1.50**
KELBRAKET No. 7 (per pair) ...	**2.00**

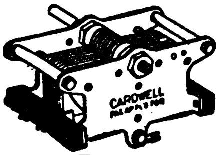
Write for the "KELBRAKET BOOK"

KELLERADIO, INC.
821 Market Street San Francisco, Cal.

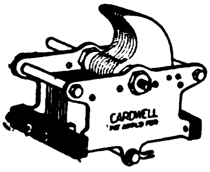


FROM SLC TO SLF

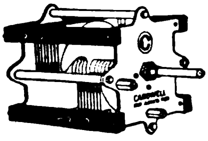




Type B



Type C



Type D

A CONDENSER to possess real efficiency, must have negligible losses and retain its calibration at all times. These are the cardinal virtues of Cardwells. That they were the original "low loss" type, suggests that they must be so excellent in all other respects that they are the final perfection in condenser art.

Because of their inherent efficiency, they are readily adaptable to straight-line design, which affords conveniences at the dial in logging. Thus, without resorting to peculiar looking construction, the Cardwell can be made in SLW, or SLF, without sacrificing its basic advantages: extreme rigidity and constant calibration.

Note that Type B (SLC) is converted into SLW by using the Cardwell Equitrol dial. This is shown in terms of frequency above and in terms of wavelengths in the small graph. Type B is more "selective" than most SLF types. With the Equitrol, you have more dial visibility than with any 180° SLF condenser. Type C gives semi-SLW tuning. Type D is for SLF service, No. 217 being a dual, balanced type recommended for all TRF circuits.

WRITE FOR BOOKLET K-77.

SERIES B

Type	Cap*	Price
154B	150	$4.00
141B	250	4.25
153B	300	4.50
152B	350	4.75
123B	500	5.00
137B	1000	6.00

SERIES C

Type	Cap*	Price
168C†	130	$4.00
170C†	250	4.25
192C†	300	4.25
171C†	340	4.50
173C†	500	5.00
175C†	1000	7.75

SERIES D

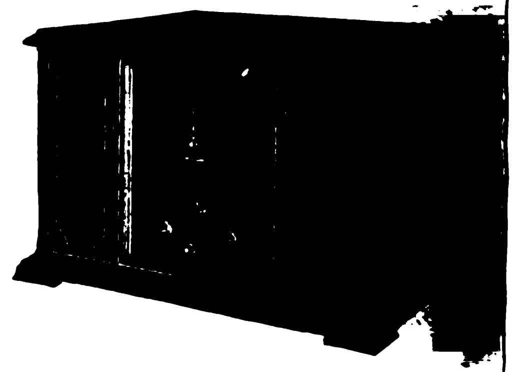
Type	Cap*	Price
217D†‡	330	$8.00
173C†°	240	$5.00
174D†°	320	5.50
193D†°	340	6.00
194D†°	400	6.50
175D†°	440	7.00

*MMF. †Specify "R" for clockwise. "L" for counterclockwise. (Add "V" to any type number for built-in vernier, adding $1.50 to list price of plain type.) ‡Dual. °Singles. Over 100 other types not listed.

ALLEN D. CARDWELL MFG. CORPORATION, 81 Prospect St., Brooklyn, N. Y.

CARDWELL

The LE MOR UNI-CONTROL Receiver



At last—true single dial control, without loss of volume or tone, is a complete reality. It is made possible through "Pretuning"—an exclusive LE MOR development. All variations in the three condenser units, however slight, are literally IRONED OUT, after assembly, at the factory.

One dial and ONLY ONE is positively effective in giving the maximum volume possible for the weakest stations. Tuning is simple, quick and certain. Stations cannot be passed over for the set is in perfect tune at every point on the dial.

You actually sweep the country with the turn of a single knob.

Straight line frequency condensers, acoustically improved audio circuits, attractive walnut cabinet with ample battery space are a few of the many features to be found in the LE MOR UNI-CONTROL receiver.

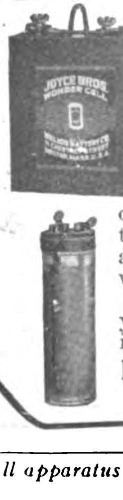
Guaranteed—absolutely.

LEMOR
RADIO INC
ASBURY PARK, N. J.

WRITE FOR FOLDER DESCRIBING PRETUNING IN FULL. Distributors franchises now being issued.

JOYCE BROS. Wonder Cell!

Replaces Dry Cells

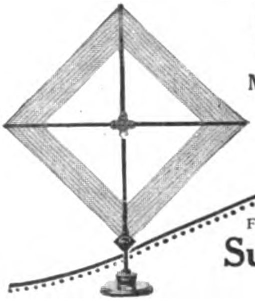


Marvelous, new, patented storage battery. A marked advance in the radio field. Storage efficiency at dry cell cost. Rechargeable from lighting circuit for a few cents. Suitable for different tube voltages—2-4-6 volts, and for transmission as well as reception.

Insist on Wonder Cells at your dealers. For further information write direct to

HELIOS BATTERY CO.
71 Chestnut St., Boston, Mass.

KORACH



Tuned Loop
Multiple Switch Board Tuner
Directional
Base Compass for Logging
Collapsible

For those who demand
Superior Results

Leads the march toward perfect radio reception under all conditions. Not merely a "loop" but an ingenuous arrangement of mechanical skill designed for superior results. L. M. Cockaday, using this loop, reached out across the Atlantic to audibly hear many trans-continental Stations.

Selectivity Plus Distance

unheard of with common loop aerials. The Korach excels on all sets designed for loop reception. Priced at $16.50 and for sale by all good dealers. Full particulars sent for 2c stamp and name of local dealer.

KORACH RADIO CO.
20 E. JACKSON BLVD. Dept. 10 CHICAGO, ILL.
Dealers and *Jobbers:* Write today for attractive propositions.

THE KORACH JUNIOR
A modification of the "Senior" but possessing all its important features - - - $12.50

Ward's New Radio Catalogue is Now Ready

Are you interested in seeing what is new in Radio — what is best and what has been approved?

And do you wish to know the lowest prices on tested sets, prices made without the usual "Radio profits?"

This Catalogue is a Complete Guide to Radio

Ward's is headquarters for Radio, with probably the largest retail radio department in the whole world.

This new 52 page Radio Catalogue shows everything in parts, batteries, cabinets, contains a list of stations, a radio log for recording stations. It shows the best of the new sets. One tube sets that give amazing results. Five tube sets with a single dial to turn. Think of tuning in one station after another by turning a single dial!

Every price quoted means a big saving to you. Everything offered is tested by our own Radio Experts. In fact, the best experts compiled this Catalogue for you.

Write for this 52 Page Book. It is yours free.

Our 53 year old Policy

For 53 years we have sold only quality merchandise under a Golden Rule Policy. You can rely absolutely upon the quality of everything shown in this Radio Catalogue.

Write to the house nearest you for your free copy of Ward's new Radio Catalogue. Address Dept. 38-R

ESTABLISHED 1872
Montgomery Ward & Co.
The Oldest Mail Order House is Today the Most Progressive
Baltimore Chicago Kansas City St. Paul Portland, Ore. Oakland, Calif. Ft. Worth

ELKAY

FIVE-TUBE
SUPER-SELECTOR

Needle-Point
SELECTIVITY $80

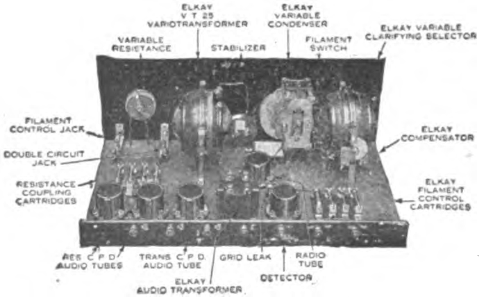
Elkay owners almost under the aerials of great B. C. stations say they can easily tune out all local signals and bring in DX, clear and loud, from all directions.

This "needle-point" selectivity is due to high grade parts and careful balancing throughout, but especially to the ELKAY VARIABLE CLARIFYING SELECTOR in the antenna circuit.

Besides this, in the Elkay Super-Selector combined *resistance* and transformer coupling gives you remarkable sweetness, clarity and naturalness of tone.

These points, together with complete control of oscillation and an R. F. device that affords the same smooth operation on the low as well as on the high wave lengths, go to make the Elkay a very desirable set for general broadcast reception.

In handsome mahogany cabinet—for 5 tubes, $80; for four tubes, $70. Write for folder. (Amateur set builders get our kit prices.) TO THE TRADE: Write for exclusive territory.



THE LANGBEIN-KAUFMAN RADIO CO.
Dept. P. 511 Chapel St., New Haven, Conn.

An L·K Product

TUNERS ELKAY SETS, KITS

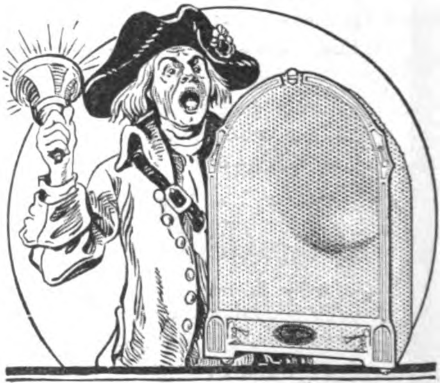
AEROVOX

Manufacturers of
Fixed Condensers

The Aerovox Wireless Corporation sincerely wishes you a Merry Christmas and a Happy New Year.

We take this joyous occasion also to thank our many friends for their esteemed patronage during the past year; and promise to continue deserving their good will and confidence during the coming year.

AEROVOX WIRELESS CORPORATION
491 Broome Street - - - - - - - New York



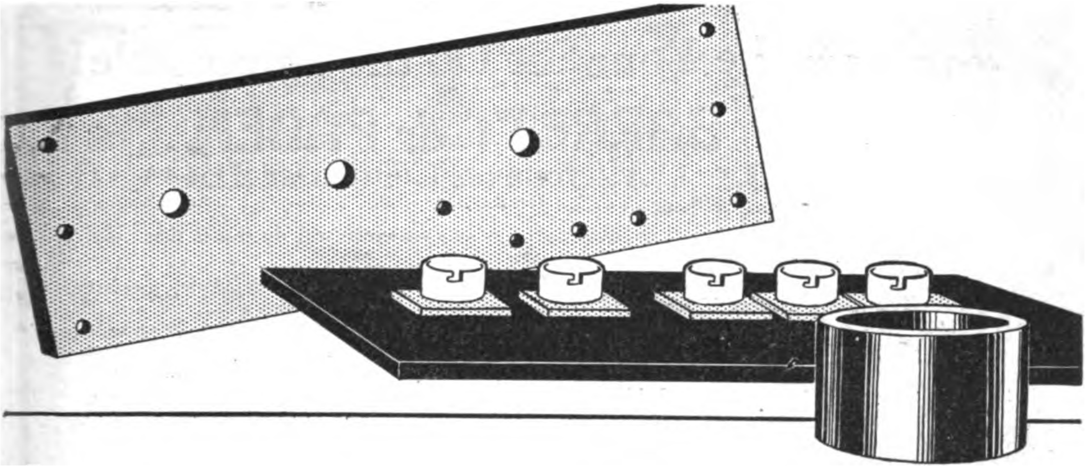
The TOWN CRIER
Radio's Most Beautiful Speaker

WRITE today for beautifully illustrated circular describing the Golden Polychrome and the Green Polychrome Models.

You will be delighted with the gorgeous colors—the handsome, stippled finish, and the artistic design of the Town Crier—"the speaker with the voice that thrills." Ask your Dealer to show you a Town Crier.

List Price $17.50
West of the Rockies $18.50

GALE RADIO LABS.
2512 Irving Park Blvd. CHICAGO



The big advantage of Formica Panels

VERI-CHROME PANELS

By the purchase of a controlling interest in the Veri-Chrome laboratories, the financial and production resources of the Formica Insulation Company have been placed behind this remarkable new process for decorating radio panels. Elaborate decorations can be produced much more rapidly and more economically than by engraving. Decorations designed by the leading American artists are offered. Tuning scales may be marked directly on the panel eliminating the standard dial and substituting pointers instead. The reduction in cost is large. Write for prices on complete panels finished in this way in quantity.

A HANDSOME finish that looks "like a million dollars" and stays so without discoloring, crazing, checking or changing in any way is one of the important characteristics of Formica. It makes sets easier to sell.

Formica has mechanical strength to provide a radio set with a thoroughly strong and sturdy framework. It will not break in any ordinary accident. It will not warp and distort in humid weather throwing the instruments out of alignment or causing trouble.
The electrical qualities of Formica get better with use. It is an essential material in a high-grade set for base panels, terminal trips and similar parts.

The better finish, and greater uniformity of Formica have made it the preferred insulating material of the overwhelming majority of the leading American set makers.

Dealers: Home set builders know and prefer Formica. It has been a highly profitable account for radio jobbers and dealers everywhere.

THE FORMICA INSULATION COMPANY
4641 Spring Grove Avenue, Cincinnati, Ohio

1 **Formica is used by nearly all the leading set makers—and has for years been used by more set makers than any other material.**

2 **Formica is unaffected by weather and time—it lasts forever.**

3 **Formica in appearance is the finest of all panel materials and always remains so.**

4 **Formica's electrical qualities of every kind far exceed any possible requirement.**

5 **Formica has high mechanical strength and will not break in use.**

6 **Formica will not sag from heat or cold flow under pressure. It retains its dimensions. Everything you fasten to it stays tight and precisely where you put it.**

7 **Formica panels are sold in neat craft paper envelopes which assure you that you are getting the genuine.**

8 **Formica is one of the most widely approved materials in radio.**

SALES OFFICES

New York, 50 Church St.
Chicago, 9 S. Clinton St.
Cleveland, 516 Caxton Bldg.
Rochester, 327 Cutler Bldg.
Toledo, 419 Ohio Bldg.
Minneapolis, 1026 Second Ave. S.
New Orleans, Whitney Central Bldg.
Pittsburgh, 422 First Ave.

San Francisco, 585 Mission St.
Philadelphia, 725 Bulletin Bldg.
Baltimore, 709 Title Bldg.
Habana, Cuba, 55 Calle Obispo
Boston, 6 Beacon St.
Denver, 1420 16th St.
St. Louis, 1362 Syndicate Trust Bldg.

FORMICA
Made from Anhydrous Bakelite Resins
SHEETS TUBES RODS

Hear the Formica Orchestra over WLW every Tuesday evening from 9 to 10 Central Standard Time.

The
Only True
Micrometer
Type
Condenser

Make Your Set Do the Impossible!

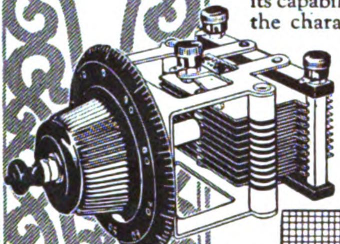
BARRETT & PADEN

Micrometer Condenser

(for Any Type of Set)

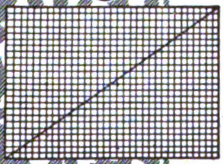
THERE is real enjoyment in having a set which will do things that other sets can't even attempt to do.

When you install Barrett & Paden condensers in any set you immediately increase its capabilities manyfold. These condensers bring in stations which, because of the characteristics of your other condensers, could not be found. Separating stations which are closely upon one another is easy and positive because of the wider range of minute capacity variations which this and only this condenser has.

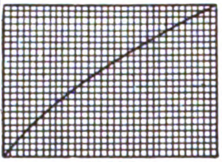


The **Barrett & Paden Condenser** works like a mechanic's micrometer. Just as this latter mentioned device makes possible the laying-off and determination of minute distances, so the Barrett & Paden Micrometer Condenser makes it possible to obtain the minute capacity variations so necessary for precision tuning.

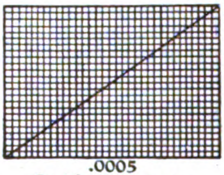
Build your next set with Barrett & Paden Micrometer Type Condensers. The tremendous difference in performance will amaze you. You will have a set which will do things almost beyond the belief of anyone who has not seen the set in actual operation. At your dealers or direct.



.00025
Straight Line Wave Length



.00035
Flat Wave Length Curve



.0005
Straight Line Capacity

.00025—straight line wave length
.00035—flat wave length curve
.0005 —straight line capacity
$6.00 *including dial*

BARRETT & PADEN
1314 Sedgwick St., Chicago, Ill.

Prepared by Kirtland-Engel Adv. Co., Chicago

Wonderful Volume with Clearness—AMPL-TONE

$3.00

Phonograph makers have spent years perfecting the acoustic properties of their phonographs. Use an AMPL-TONE Unit and make a real Loud Speaker in an instant or use it in your horn and get better results.

After all, speakers are as good as their unit. We make a real unit at a real price. Money gladly returned if you are not entirely satisfied.

WE SELL UNITS TO MFRS.

Late at night when the family has retired, don't disturb them. Use AMPL-TONE HEADSETS. They produce the best results and are unsurpassed as a distance getter. Price $5.00.

You can buy direct from us also
The UNION FABRIC CO. DERBY, CONN.

MADE IN U.S.A.
CRESCENT BRAID CO. INC.
TRADE MARK
PROVIDENCE, R.I.
PATENT PENDING

Quick *as* *a* Wink!

PREMIER 20-ft. Extension Cord (for loud-speakers) now comes with the handiest connecting plug you ever saw. Holds terminal pins securely. Releases instantly. Automatic—with no tiny screws to fuss with or lose.

A Desirable, Useful and Inexpensive Xmas Gift.

PREMIER Cord, with Plug....... **$1.75**

At your dealer's or write us.

CRESCENT BRAID CO., Inc.

Premier 5 wire battery cable $1.00, complete with all terminals for quick connections, removes all unsightly wires.

Providence, R. I.

DISTANCE

THE OBEDIENT SLAVE TO YOUR DESIRES

Upon request, we will gladly mail descriptive Folder.

APEX mastery over the most advanced radio engineering principles makes distance the obedient slave of your desires and places at your instant command the whole continent of radio enjoyment.

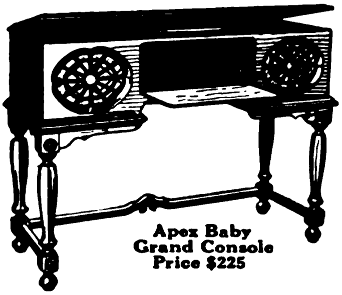
The infinite care and skill employed in perfecting the mechanical construction of APEX Radio Apparatus is radiantly reflected in the rich beauty of design, harmony of proportion and elegance of finish that stamp all APEX sets with an unmistakable mark of master craftsmanship.

You are cordially invited to inspect this complete showing of Quality Radio Apparatus. Only a dependable merchant is given the APEX dealer franchise. Your APEX dealer will gladly make a personal demonstration of APEX Quality Radio Apparatus.

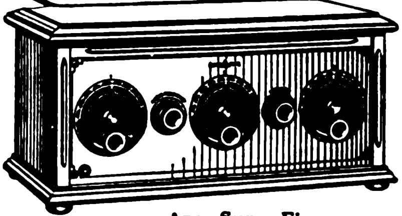
APEX ELECTRIC MFG. CO.
1410 West 59th St., Dept. 1202
CHICAGO

Also makers of the famous APEX Vernier Dials and APEX Rheostat Dials which are sold by every good dealer in Radio.

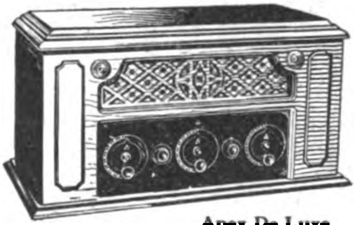
APEX
Quality Radio Apparatus



Apex Baby Grand Console
Price $225



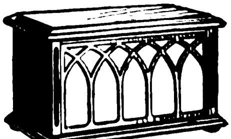
Apex Super Five
Price $95—without accessories



Apex De Luxe
Price $135

Apex Entertainer
Price $22.50

Apex Utility Radio Table
Price $75



Apex Console Entertainer
Price $27.50

Prices West of Rockies Slightly Higher. **Canadian Prices Approximately 40% Higher.**

Insure YOUR Radio Tubes

Avoid Mistakes

Equip your battery leads with these new CROWE everlasting markers. Bold markings permanently etched in black on metal.

Crowe Cable Markers
Easily Attached With a Pair of Ordinary Pliers
Contents one each of the following:
A+ B- B+AMP. C+ ORD.
A- B+DET. C- ANT.
A+

25c

A Packet of Nine

CROWE CABLE MARKERS

Easily attached with ordinary pliers

At your dealers in this display box.

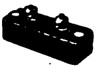
DEALERS—

Write for introductory offer, giving name of jobber.

CROWE NAME PLATE & MFG. CO.
1749 Grace St. : Chicago

MUTER

DEPENDABLE RADIO PRODUCTS

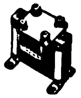


Lightning Arresters—approved by Fire Underwriters. Retail . . **50c**

Complete Aerial Kits—everything for complete installation with instructions. Retail **$3.50**

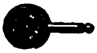
Resistance Amplifiers—

all assembled and ready for use. Retail . . **$8.00**



Audio Frequency Transformers — tests have proven the quality. Retail **$2.25**

Automatic Shock Proof Phone Plugs—a real value at this price **50c**



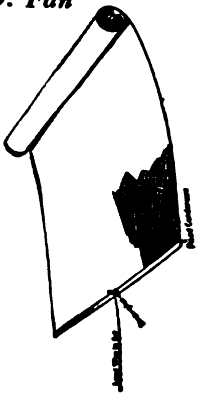
Sold by
All Leading Radio Dealers

"Twice the range and more volume on this indoor aerial!"

—says a Youngstown, O. Fan

Effarsee

ANTENNAE
REG. U. S. TRADE MARK
PATENT PENDING



Equip your set with a new EFFARSEE and watch your old distance records go! Thousands of unsightly, inefficient outside wires have been replaced with this new scientifically designed antenna.

Increases Selectivity! Cuts Down Static!

You never have trouble separating stations with an EFFARSEE, and it eliminates local interference—reception with EFFARSEE is reception at its best.

Type IXL contains 1000 feet of copper wire; type BXL, slightly smaller; both models equipped with special fixed condensers. Write for testimonials of enthusiastic users.

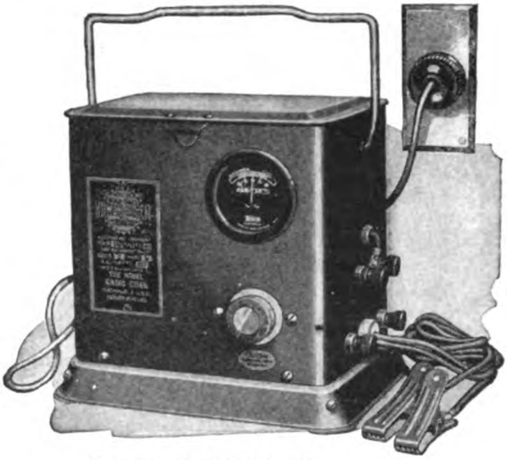
Type IXL (Large) **$4.00**
Type BXL (Small) **$2.50**
At any radio dealer or write direct.

THE FISHWICK RADIO CO.
137 Central Parkway Cincinnati, O.

The obsolete, slow 2-ampere battery charger has been put with the other relics of years ago!

Buy nothing but an up-to-date 5-ampere charger!

The New Improved
5 AMP. A & B
GOLD SEAL
HOMCHARGER
$19.50



Over 500,000 already in use

Charges in One-Third the Time!

Better Because:—

New micrometer adjustment, hinged lid, and carrying handle.

No bulbs to buy or break.

Can be used anywhere—contains no acids or other harmful liquids to spill.

Approved by underwriters—trouble-proof, shock-proof and fireproof.

Beautiful cabinet in maroon and gold.

Free *Write for new edition of our instructive booklet on radio operation "The Secret of Distance and Volume in Radio."*

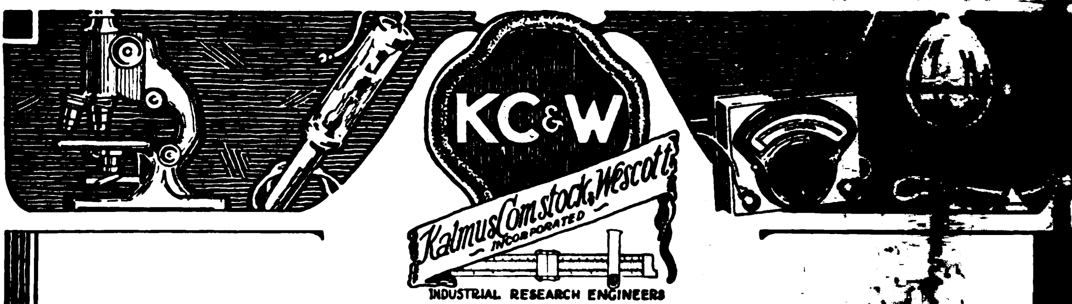
It takes only one-third as long to fully charge your battery with the New Improved 5-ampere GOLD SEAL HOMCHARGER.

No more of the long, bothersome waits that were necessary when the slow inefficient 2-ampere charger was the best that radio offered. The New Improved GOLD SEAL HOMCHARGER charges 150% faster—fully charges the average battery overnight—**and it charges both A and B batteries without additional equipment.**

Before you buy any charger be sure it charges at 5-amperes. To be absolutely sure insist on the **GOLD SEAL HOMCHARGER.**

The Kodel Radio Corporation
504 East Pearl Street Cincinnati, Ohio

WKRC
Owners of Kodel Broadcasting Station WKRC
on the Alms Hotel Send for program


KC&W
Kalmus Comstock, Wescott Incorporated
INDUSTRIAL RESEARCH ENGINEERS

"RESEARCH IS THE KEY TO THE FUTURE OF RADIO"—

says R. E. Renaud in "Popular Radio"

Radio manufacturers, radio investors and the buying public are beginning to realize the tremendous importance of research work based on science and method.

Large manufacturers maintaining research departments of their own find our services of great value for the solution of problems which arise from time to time outside the more specialized field of their own research departments.

Smaller manufacturers may now have their necessary research work done without the financial burden of maintaining research departments of their own.

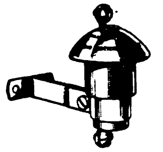
A descriptive booklet will be furnished on request.

KALMUS, COMSTOCK & WESCOTT Inc.
110-114 BROOKLINE AVE. *Industrial Research Engineers.* **BOSTON, MASSACHUSETTS**

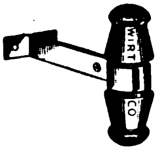
HEAR ALL YOUR AERIAL GETS

Perfect Insulation Assures Better Reception

Wirt Radio Lightning Arresters and Wirt Radio Wall Insulators assure better insulation from aerial to your set. Lower loss means greater volume.



Wirt Radio Lightning Arrester. Air Gap Type. Made of Bakelite and Brass. Wide petticoat provides ample insulation even in wet weather. Bracket for rigid fastening. Extra heavy terminals. Lead-in connects without cutting wire. Heavy brass screws for mounting. $1.00 each.



Wirt Radio Wall Insulators. Made of brown glazed porcelain. Bracket for rigid fastening. Heavy screws furnished for mounting. 35c. each.

Arresters and Insulators sent post-paid, securely packed on receipt of price.

Manufactured and Guaranteed by

WIRT COMPANY
PHILADELPHIA PENNSYLVANIA
Makers of Dim-A-Lite
5221 Greene St. Dept. B Philadelphia, Pa.

SALES AGENTS
George C. Knott, 67 Park Place, New York, N. Y.
Doherty-Hafner Co., 730 West Monroe St., Chicago, Ill.
George A. Gray Co., 910 Howard St. San Francisco, Cal.
Pass & Seymour, Inc., Export Managers, 66 W. B'way, N.Y.
Benjamin Electric Mfg. Co., Toronto, Canada

Better Results with Less Space— Using DUPLEX

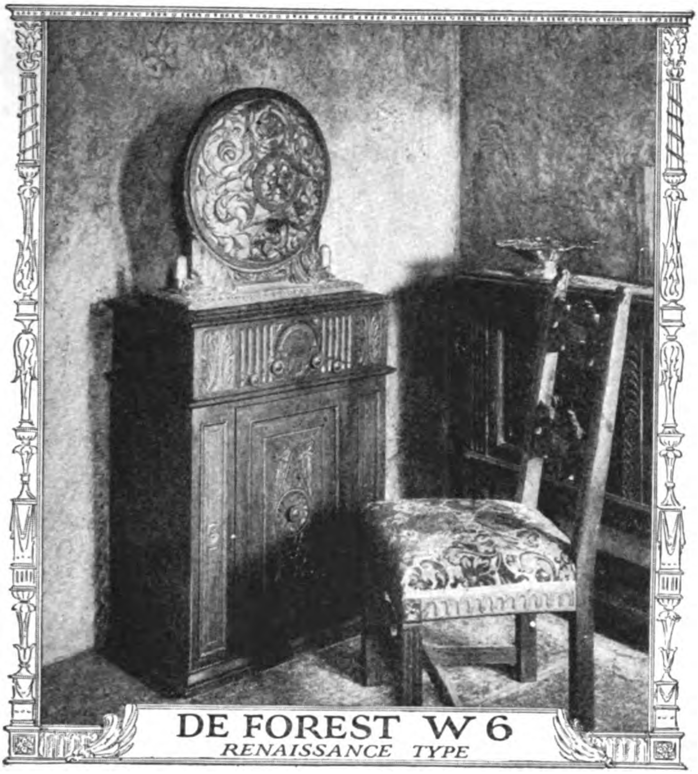
CONDENSERS

Their specially shaped-out stators afford separation on all wave-lengths, increasing selectivity and eliminating interference. Their carefully planned design retains all low-loss advantages and keeps DUPLEX S. L. F. Condensers as small as the previous models.

Learn the secret of DUPLEX superior construction. Sample plate and literature sent on request.

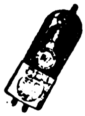
DUPLEX CONDENSER & RADIO CORP.
50 Flatbush Avenue Extension
Brooklyn, N. Y.

THE · PERFECT · UNION · OF · ART · AND · SCIENCE

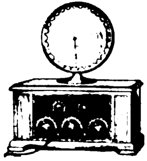


DE FOREST W6

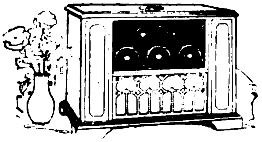
RENAISSANCE TYPE



DE FOREST AUDION is the world standard in tubes. The De Forest policy of a specific type tube for each socket insures finer reception and greater distance. Price, $8



DE FOREST F-5 AW A compact, powerful set in polished walnut that will bring joy to many a household. Has the capacity to separate stations positively so that you can pick the broadcast gems without interference. Price (minus tubes, loud speaker and batteries) $90.



DE FOREST F-5 M A superfine 5-tube set in two color mahogany cabinet with built-in loud speaker and concealed compartments for "A" and "B" batteries. Extremely simple to operate. No howling or hissing in tuning in. An unsurpassed value at $110.

De Forest Radio Sets can be bought at prices ranging from $85 to $450

De Forest Genius now *Humanizes* Radio!

MARVELOUS new circuit, just perfected, reproduces flawlessly the mellow, soft modulations of the human voice and captures the hitherto elusive overtones of the musical register .... tuning simplified .... a new ease in operation .... all embodied in the new and beautiful De Forest W5 or W6 Radiophones.

~ ~ ~

The voice of radio is no longer flinty and metallic, but mellow, human and musical—thanks to the development by Roy A. Weagant, Vice-President and Chief Engineer of the De Forest Radio Company, of a new and marvelous circuit.

This ingenious circuit makes its first public appearance in the De Forest W5 and W6 Radiophones, masterpieces of cabinet art worthy only of a scientific development so outstanding.

For the first time you get from music the overtones as well as the middle tones . . . the majestic roll of the kettle drums, the crooning of the bass viols. the strident crash of the brasses and the piping heraldry of the cornets and trombones. No incoherence, no oscillating jumble of noise—every instrument, every octave, in its true value. *A magic achievement!*

To the lover of dance music the De Forest W5 or W6 brings more sprightliness, more beauties of syncopation . . . you should hear Vincent Lopez, Joseph Knecht, The Night Hawks, or any others over either of *these* instruments!

To everything that is broadcast, the De Forest Radiophone gives animation, life and humanness.

But Tonal Supremacy is Not All—

Elbert McGran Jackson, renowned sculptor, architect, and painter, put into this handwrought, hand-carved cabinet the spirit of radio, in design, in motif—it is not an adaptation of a phonograph. An image of charming individuality, it harmonizes with the setting of any home.

One unit, everything self-contained—not a wire in sight, nothing to connect . . . and *portable;* move it any place! Only charm and beauty for the eye.

The artistic conical reproducer is an inseparable part of the cabinet and its tonal mechanism peerlessly attuned to that of the Weagant circuit. There are just two controls for tuning, and these operate on one dial, which makes the normally perplexing task of "tuning in" extremely simple. There are special power tubes in the fifth and sixth sockets which can give you volume to flood an auditorium, if you desire it. And, at your fingers' tips, the means to tune in a far-distant station you want no matter how powerful nearby stations may be.

See the incomparable De Forest W5 and W6 at your De Forest dealer's or write for an interesting booklet describing these masterpieces in detail.

De Forest Radio Co., Jersey City, N.J.

DE FOREST *The Greatest Name in Radio*

DEALERS IN ALL CITIES AND RADIO COMMUNITIES

THE EPOCH-MAKING ACHIEVEMENT WHICH MAKES ORDINARY RADIO RECEPTION A THING OF YESTERDAY

On to Success in RADIO!

Mr. R. L. Duncan
Director of the
Radio Institute
of America

RADIO is a profession well worth following. The work is interesting—fascinating. The pay is high. The demand for new men—skilled men—is strong.

You can embark, right now, on a successful career in radio. With a few months study under the expert instruction of the Radio Institute of America you can pass your U. S. Government Commercial or Amateur Radio License Examination and be ready for your first real radio job.

Study in spare time

There's no need to give up your present work. Study at home in spare time. If you really want to make a success in radio, fill in and mail the coupon to the Radio Institute of America for information on the finest theoretical and practical radio courses offered today.

RADIO INSTITUTE OF AMERICA

Formerly Marconi Institute
Established in 1909

322-A Broadway New York City

Radio Institute of America
322-A Broadway, New York City

Please send me full information about your Home Study Course of radio instruction.

I am interested in the complete course, including code instruction, which qualifies for the U. S. Gov't. Commercial or Amateur Radio License.

Name..

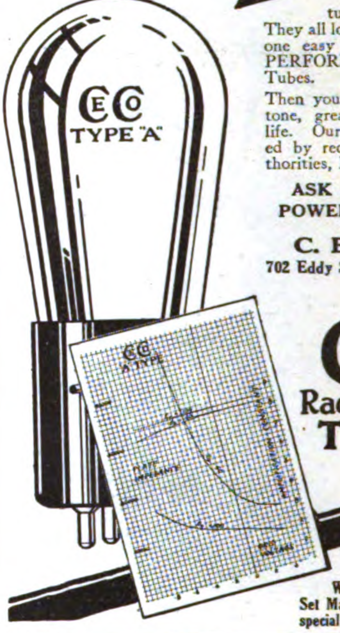
Address..

....

---

makes a good receiver Better

Types A B C
6V. 3V. 3V.



You can't judge tubes by appearance. They all look alike. But there's one easy way to be of sure PERFORMANCE. Buy *CECO* Tubes.

Then you'll get clearer, richer tone, greater volume, longer life. Our test charts, confirmed by recognized national authorities, PROVE this claim.

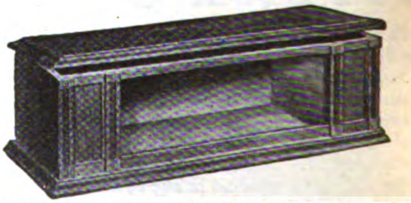
ASK ABOUT CECO POWER AMPLIFIERS

C. E. Mfg. Co.
702 Eddy St. Providence, R. I.

CECO
Radio Vacuum TUBES

Trade Supplied thru Jobbers Only. Jobbers—Write for details and prices. Set Manufacturers—Ask about our special matched tubes.

Premier B Battery Cabinet



Our Premier B Battery Cabinet is a beautiful piece of furniture. The B battery compartment will take any type B battery. The space of each B battery compartment is 4½" wide, 8½" high and 10" deep.

No.	For Panel	Deep	Genuine Walnut
718-10	7 x 18	10"	$18.50
721-10	7 x 21	10"	19.00
724-10	7 x 24	10"	19.50
726-10	7 x 26	10"	20.00
728-10	7 x 28	10"	21.00
730-10	7 x 30	10"	22.00

F.O.B. Waukesha, Wis.

The tops of these cabinets are figured walnut, the ends and B battery panels are select walnut, all 5 ply veneer. The bases are built up of massive molding. Nickel plated piano hinges and lid holders. The material and finish in these cabinets will equal the best furniture obtainable.

WE MAKE 9 STYLES OF CABINETS FOR 14 SIZES OF PANELS. Send for our 1925-26 line of cabinets at "Factory to User" prices.

Utility Cabinet Company
Phone 721 Waukesha, Wisconsin

Do your BATTERIES *fail*— when you want them most?

Now—you can be certain of continuous, unfailing "A" power of the highest quality . . . and always at full voltage

• • •

A DELIGHTFUL PROGRAM *that you've been looking forward to. A circle of friends to share it with you. Your radio is working perfectly. Then the rich, clear tones begin to fade. Embarrassed, you start to tune and tinker.*

Your "A" batteries failed—just when you wanted them most!

AN experience that comes to every radio fan! For "A" battery failure is the most frequent cause of poor radio reception.

But *to you*—this need never happen again. For you can now have continuous, unfailing "A" power that *automatically* replenishes itself from your house current.

Unipower—a triumph in radio engineering

Unipower is a single compact "A" power unit that fits *inside* most radio cabinets. It takes the place of dry cells or separate storage battery and charging units.

Unipower comes to you completely wired and assembled—all you have to do is connect two wires to your set and plug in on your house current. Unipower is equipped with an exclusive Balkite charger of special design. Unipower will last you for years, and has no tubes, bulbs, lamps or working parts that require frequent and expensive replacement.

A unique feature of Unipower is the master-control switch that governs the operation of your entire set. When the switch is ON, Unipower feeds your set rich, quiet power with neither hum nor noise. When the switch is OFF, Unipower *automatically* replenishes itself from your house lighting current.

Unipower is not a battery eliminator, and should not be confused with any other power device. Unipower is a scientifically designed "A" current supply which automatically converts house lighting current into radio power.

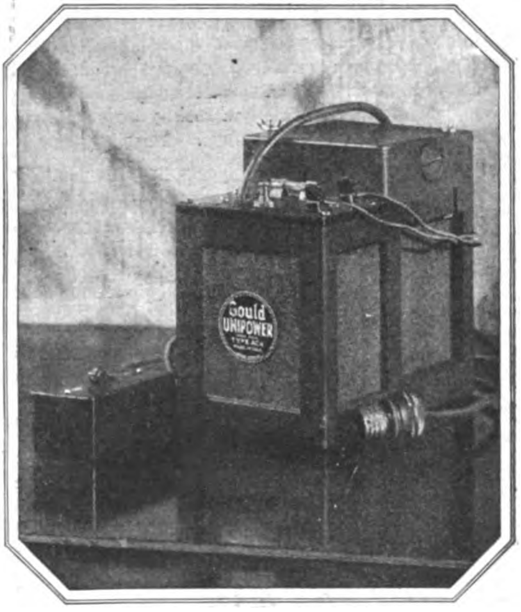
Take time today to see Unipower at your radio dealer's. He will be glad to demonstrate it and explain its features to you. The Gould Storage Battery Company, Inc., 250 Park Avenue, New York.

The standard Unipower operates from alternating current, 110-125 V-60 cycle. It is supplied in two types. The 4 volt type is for sets using U V 199 tubes or equivalent and retails for $35.00. The 6 volt type is for sets using U V 201-A tubes or equivalent and retails for $40.00. West of the Rockies, prices are slightly higher. (Special models, 25-50 cycle, are available.)

FREE!

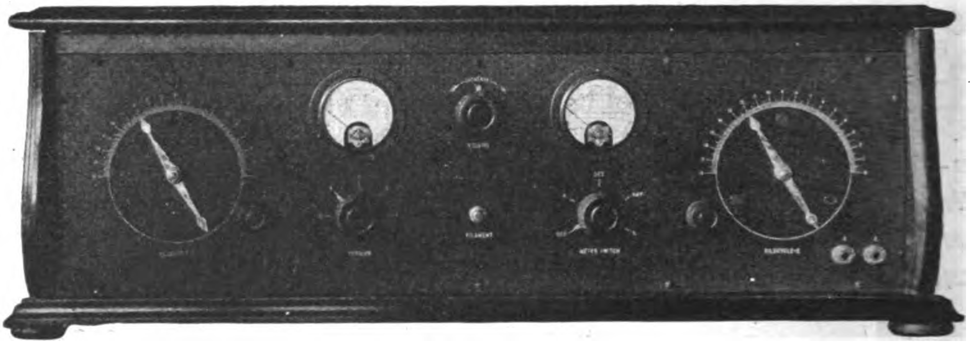
Write for interesting booklet, "Unipower — a Triumph in Radio Power", describing Unipower's many advantages and economies.

THE UNIPOWER ILLUSTRATED HERE IS FOR SETS USING UV-199 TUBES OR EQUIVALENT. FITS COMFORTABLY INSIDE MOST CABINETS.



Unipower TRADE MARK

Off when it's on—On when it's off



The Best in the World

No Batteries are required even to operate the most powerful 10-tube receiver.

We have experimented with many types of "Eliminators" and now recommend without qualification the

Model A Power Unit

One Customer Telegraphs:

"Receiver assembled, performing like a thorobred."

The Amateur or Experimenter with his ultra-modern high-powered receiver is years ahead of Commercial Radio.

It is significant that unsolicited testimonials are constantly being received from even the far corners of the earth, where Norden-Hauck Engineers have furnished the finest radio apparatus known to the art today.

Quotations gladly furnished on radio parts and apparatus having non-infringing uses.

Write for Literature

NORDEN-HAUCK, INC.

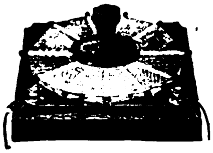
Engineers

1617 Chestnut Street, Philadelphia, Penna.

Steinite LOW LOSS Interference Eliminator

No Radio Set Complete Without It

Now you can select stations at will, cut out interference and undesired stations—tune in loud and clear. **Wonderful results with any tube or crystal set** using any kind of aerial except loop antenna. Partially absorbs static.



$1 Post-paid **Amazing Results, Better Reception Guaranteed or We Refund Your Dollar. Send Order Today.**

Select Stations At Will

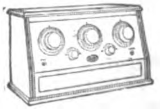
Try this Interference Eliminator on your set—no tools—nothing to add—attached in 2 minutes to aerial. Doesn't disturb present log. Directions easy to follow. Two big banks testify to our reliability. Order today—dollar bill will do—we take the risk—money back if you say so.

STEINITE LABORATORIES
301 Radio Building, ATCHISON, KANSAS

Write for complete Steinite Radio literature—it's FREE. Most beautiful and least expensive radio sets in America.

If you want the best!

Pathe Sets Operate on House Current



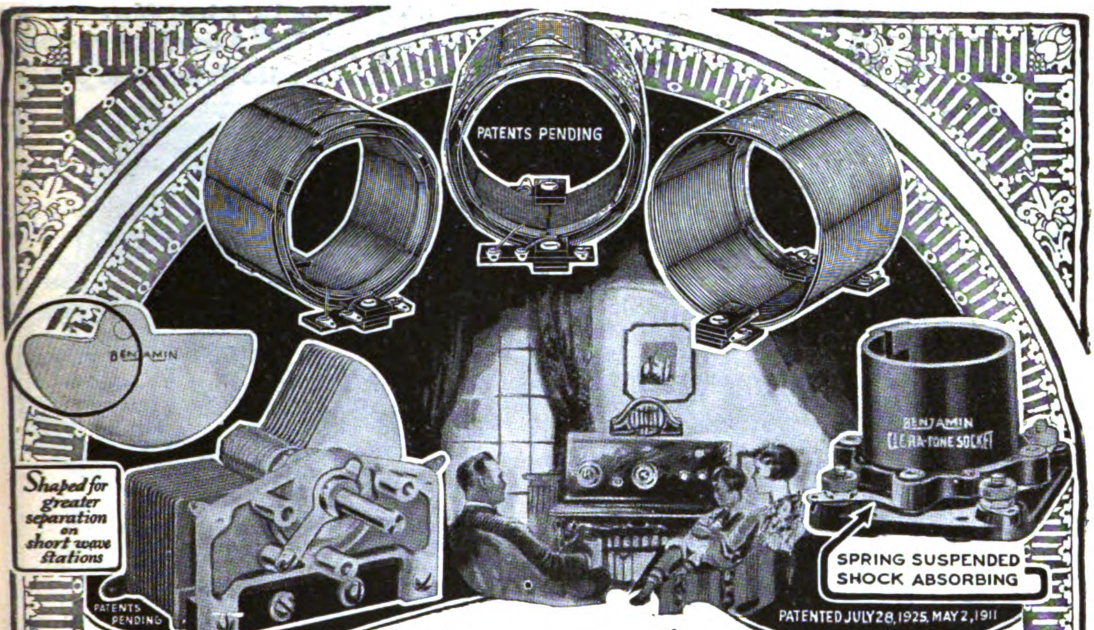
Pathé

CONE LOUD SPEAKER

Exquisite in tone
Exquisite in design
Exquisite in workmanship

Some territory for both jobbers and retailers still open. Write

PATHÉ PHONOGRAPH AND RADIO CORPORATION
Dept. 49 20 Grand Avenue, Brooklyn, N. Y.


PATENTS PENDING
BENJAMIN
Shaped for greater separation on short wave stations
PATENTS PENDING
BENJAMIN CLE-RA-TONE SOCKET
SPRING SUSPENDED SHOCK ABSORBING
PATENTED JULY 28, 1925, MAY 2, 1911

Accepted
by the Radio World

Benjamin Radio Products have set New Standards of Tonal Quality and Volume

The use of Benjamin Radio Products brings a new joy and an immeasurably greater satisfaction into radio reception.

Individually, each Benjamin radio part improves that radio function for which it is designed. When taken all together and their aggregate advantages added to any set, "Better Radio Than Ever" is inevitable.

Benjamin Tuned Radio Frequency Transformers

Even in what has been considered an excellent set, it is astonishing what an improvement in tone, quality, volume and selectivity the introduction of these coils produces. Low Resistance. Low Distributed Capacity. Uniform both in inductance and distributed capacity. Space wound, air core; double green silk insulation—the nearest approach to an all-air dielectric construction and the highest type of inductance possible. Coils are coupled so as to reduce capacity coupling to a minimum.

Benjamin Low Loss, Long Range Condensers

First of all a wonderful low loss condenser. The shape of the rotor blades spreads the broadcast range on the lower wave lengths, eliminating bunching of stations on the lower side of the dial and makes tuning very easy. A beautiful instrument, in unpolished silver plate finish. Friction disc on rotor shaft adjusts turning tension without loosening or throwing plates out of alignment. Made in three sizes: 13 plate for .00025 Mfd., 17 plate for .00035 Mfd., and 25 plate for .0005 Mfd. Drilling template furnished with each condenser.

Benjamin Cle-Ra-Tone Sockets

Benjamin Cle-Ra-Tone Sockets prevent the transmission of outside vibrations into microphonic disturbances. Four delicately adjusted double springs support the socket—"float" it above the base—and absorb all jars and shocks. Handy lugs makes soldering easy. Furnished also in gangs on Bakelite sub-panels for compact set building. *Now ready*—the new "Push" type Cle-Ra-Tone Sockets for Standard UX "Push" type tubes.

BENJAMIN

Benjamin Electric Mfg. Co.

120-128 South Sangamon Street
Chicago

247 W. 17th Street
New York

448 Bryant Street
San Francisco

Manufactured in Canada by the Benjamin Electric Mfg. Co., of Canada, Ltd., Toronto, Ontario

Enameled Antenna

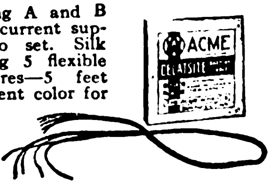
Stranded

The best outdoor antenna you can put up. 7 strands of enameled copper wire; maximum surface for reception. Enameling prevents corrosion and consequent weak signals. 100, 150 or 200 ft. coils, boxed.

Loop Antenna Wire

You can make a good loop with Acme wire made of 65 strands of fine copper wire, green silk covered. Flexible; non-stretching, neat.

Celatsite Battery Cable



For connecting A and B Batteries (or current supply) to radio set. Silk braid covering 5 flexible Celatsite wires—5 feet long—a different color for each terminal. Prevents messy wiring and "blown" tubes. Adds greatly to the appearance of your set.

The Original Celatsite Wire

Celatsite is a tinned copper bus bar wire with a non-inflammable "spaghetti" insulation in five colors. Supplied in 30 inch lengths.

Flexible Varnished "Spaghetti"

A perfect insulation tube for all danger points in set wiring. Costs little more than the cheaper substitutes offered. Black, yellow, red, green, brown; for wires No. 10 to No. 18. 30 inch lengths.

Flexible Celatsite

Flexible stranded wire for "point to point" and sub-panel wiring—latest method of wiring sets. 5 colors; black, yellow, green, red and brown, one for each circuit. 25 ft. coils.

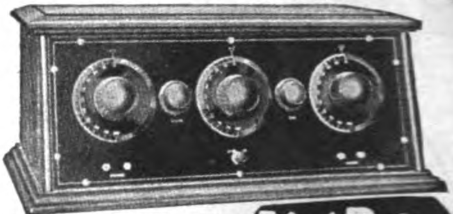
Send for folder

THE ACME WIRE CO.

Dept. P. New Haven, Conn.

TREGO The World's Lowest Priced

5-Tube Tuned Radio Frequency Set



Coast to Coast Range

List Price $45.00

HERE'S the set that sells and satisfies! It's the TREGO 5-Tube Tuned Radio Frequency Set—highest quality at a price within the reach of all. Retails at only $45.00. Gives you Big Profits. Sells 10 to 1 over higher priced sets. Millions want it! Storage or dry-cell operation. Backed by our Iron-Clad Guarantee. Sold only through dealers.

Send for Monthly Catalog and exclusive dealer plan. This TREGO TRF5 is only one of the hundreds of profitable quick-selling items listed—just off the press. Get your copy now—cash in on the fall and winter radio demand.

TREGO RADIO MFG. COMPANY

Manufacturers and Wholesale Distributors

1431 Chestnut St., Kansas City, Mo.

"Lighted Continously 72 Days—and Still in Good Receiving Condition"

One astonishing report of the many hundreds received proves unmistakably Sea Gulls' exceptionally long life. A user kept six Sea Gull Tubes lighted for over 1700 hours and found them all operating efficiently at the end of the period.

Sea Gull Tubes have four points of superiority. 50% longer life, high mutual conductance, uniformity, interchangeable at any stage, and they are positively non-microphonic.

At your Dealer $2.50 or by mail plus parcel post

Tube R	Rectifying Tube	$3.00
Tube P	Semipower Tube	$5.00
Tube X	Double Duty Rectifier Tube	$5.00

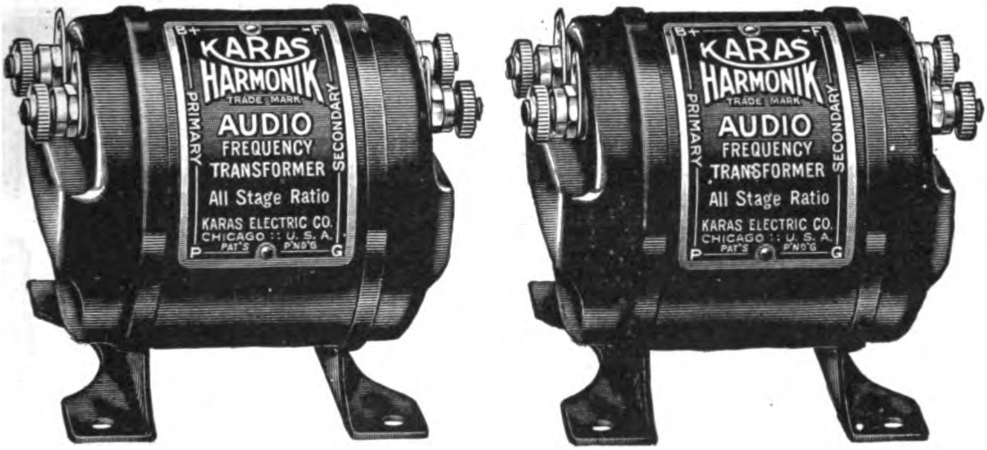
Dealers and Jobbers write us for full information and discounts

ABERDEEN SPECIALTY CO., INC.

Main Sales Office

Suite 411 1301 Chestnut Street Philadelphia

For Long Distance *with* Big Volume *and* Keen Musical Quality



-*Install a pair of* KARAS Harmonik Transformers *in your radio set*

KARAS Harmonik Transformers deliver perfect music with loads of volume from stations one to two thousand miles away. Distant reception worth listening to!

With Karas Harmoniks in your set, you can truly enjoy radio broadcast music from near or from far. You can get it in all the volume desired without crowding your receiver to the distorting point. You can sit back in your easy chair and listen with keenest pleasure.

"Fishing" for distant stations becomes a matter of finding programs you want to hear—not straining to catch only the bare announcement, and compiling a list of call letters.

There's power and to spare in Karas Harmoniks. Power that brings the biggest volume without distortion. You hear big, full, round, sonorous tones because you get the *complete* musical tone. All the vital harmonics and rich overtones are there in all their naturalness. Low notes, middle notes and high notes all are amplified to the same degree — a rare achievement for audio frequency transformers.

The true characteristics of all musical tones are recreated in your speaker. Piano music pours forth with the rich beauty of the concert hall. The pure, liquid tones of a violin played a thousand miles away cannot be detected from from those of a violin played in the same room. The inflections of the human voice are all retained—the very breathing at the microphone—the soft elusive sounds of S and Z.

If this is the kind of reception you want — whether distant or local, you must have Karas Harmoniks in your set. It's the only way you can get it over the radio. Don't wait to build a new set. Take the old transformers out of your present set and install a pair of Karas Harmoniks. The sooner you do, the sooner you will enjoy the highest quality of radio reception.

KARAS ELECTRIC CO., 4060 N. Rockwell St., Chicago

For over 30 years makers of PRECISION Electrical Apparatus

$7.00 Each

at your Dealer's ***30 Day money Back guarantee***

—wherever you buy. If your dealer is out, order direct on this coupon. Send no money. Just pay the postman.

Karas Electric Co.
4060 N. Rockwell St., Chicago, Ill.

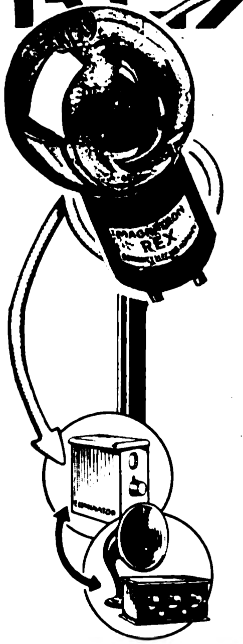
Please send me..........pairs of Karas Harmonik Audio Frequency Transformers. I will pay the postman $7 apiece, plus postage, on delivery. It is understood that I am privileged to return the transformers any time within 30 days if they do not prove entirely satisfactory to me, and my money will be refunded at once.

Name ....

Address..

....

If you send cash with order we'll send Transformers postpaid.



REX

for your 'B' battery eliminator

REX answers the eliminator problem. The B Battery eliminator equipped with Magnatron Rex tubes works day in and day out—silently and economically.

Magnatron Rex is the product of long research by the oldest exclusive manufacturers of thermionic valves in the country. It has been designed primarily and only for eliminator work.

Magnatron and Excellence have come to mean one and the same thing. Impartial laboratories and radio engineers throughout the country have certified this. Their reports explain why Magnatrons in your set will make it function better.

Your dealer has the Rex as well as the other Magnatrons. Ask him today!

They list for only $2.50.

Write for your FREE copy of "Pot Pourri—a snappy review of mirth and music," to Dept. P.R.

CONNEWEY
ELECTRIC LABORATORIES
Magnatron Building, Hoboken
New Jersey

West Coast supplied from complete stocks carried by PACIFIC RADIO LABORATORIES, 256 South Los Angeles Street, Los Angeles, California.

MAGNATRONS

22½ Volt un-acid everlasting rechargeable "B" Storage Battery

$2.95

includes chemical

45 volts $5.25, 90 volts $10.00, 112½ volts $12.50, 135 volts $14.75, 157½ volts $16.80. Truly the biggest buy today. Easily charged on any current including 32 volt systems. Any special detector plate voltage had. Tested and approved by leading authorities such as POPULAR RADIO laboratories. Over 3 years sold on a non-red tape 30 day trial offer with complete refund if not thoroughly satisfied. Further guaranteed 2 years. Knock-down kits at greater savings. Complete "Hawley" "B" Battery charger $2.75. Sample cell 35c. Order direct—send no money—simply pay the expressman cost on delivery. Or write for my free literature, testimonials and guarantee. Same day shipments.

B. HAWLEY SMITH, 315 Washington Ave.,
Danbury, Conn.

"How to Build Your Radio Receiver"

As a special inducement for you to send in your subscription during the month of December you may have a copy of "How to Build Your Radio Receiver," the most complete and authoritative collection of material on Receiver Construction yet published in book form, which gives all working details, lists of parts required, complete hook-ups and circuit diagrams (see page 104),

and

Popular Radio

with which is combined

The Wireless Age

***for* 7 Months**

BOTH for only $2.00

POPULAR RADIO
Department 127
627 West 43d Street New York City

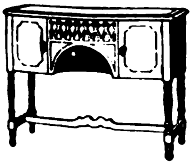
Valley
Radio Receiver

This new principle of radio is exclusive in the Valleytone

Appearance

The Valleytone is mounted in a solid walnut cabinet, finished in two tones with inlaid gold stripes. It may also be procured in beautiful console models. Special Valley tables with built-in loud speaker may be obtained for the cabinet model.

Valleytone Console Model



Valley table with built-in loudspeaker

Set the dials of a Valleytone for any station you choose. Bring in the signals strong and clear.

Then turn the dials one point beyond or back from the correct tuning. You merely diminish volume. The quality of the signals remains the same. There is no incoherent babble of noises.

Turn the dials two or three points either way from the correct tuning. Your program is gone.

Such tuning is possible only in the Valleytone. It is due to the *potential balance* method of preventing distortion and oscillation ▾ ▾ ▾ a new principle for radio which is exclusive in the Valleytone 5-Tube Radio Receiving Set.

The *potential balance* gives a balanced tone to the Valleytone. The results are an amazing clearness and naturalness of reproduction. If you have never heard the Valleytone, a new experience in radio reception awaits you.

The *Valley Toroidal Coils* make possible a selectivity not previously achieved. Stations four or five meters apart can be brought in clearly and distinctly one after the other whether they are distant or local stations.

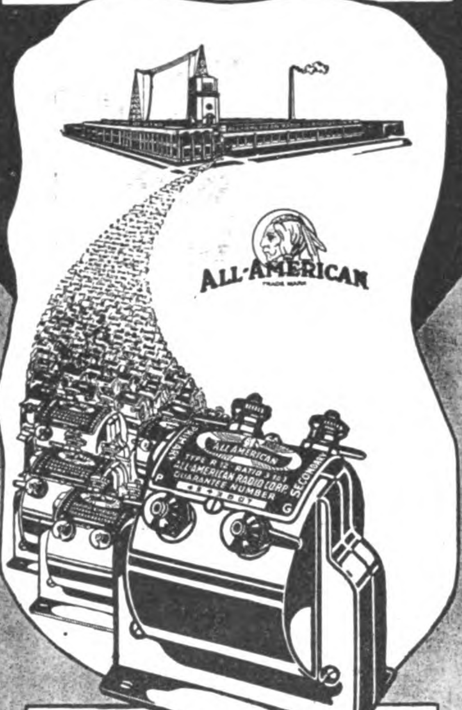
Before you buy a radio, hear the Valleytone. Judge it by results. Avoid regrets later by listening to the Valleytone now. Any authorized dealer will be glad to demonstrate the Valleytone for you.

VALLEY ELECTRIC COMPANY, *Radio Division*, ST. LOUIS, U.S.A.
Branches in Principal Cities

Valleytone Receiving Sets	**Valley Battery Chargers**	**Valley B-Eliminators**

Valley Electric

AMERICA DEMANDS MILLIONS



Year after year the supreme high precision quality of ALL-AMERICANS is demonstrated by their continued leadership—

Largest Selling Transformers in the World

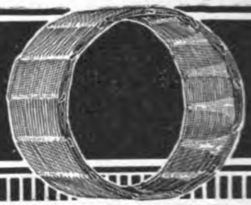
ALL-AMERICAN RADIO CORP.
E. N. RAULAND, *President*
4211 Belmont Ave. Chicago

OWNING AND OPERATING
STATION WENR—266 METERS

ALL-AMERICAN

Pioneers in the Radio Industry

A-P COILS COILS



SUPER-SOLENOID.

EFFICIENT RADIO COILS
Require
A Specialized Organization for Economical Production

We make Coils only. Our entire resources are devoted to Coils.

For that reason we are able to render Manufacturers an unequaled coil service.

Regardless of your own facilities you will undoubtedly find this service profitable to you. Ask us for estimates and samples.

COILS ACME PRODUCTS Co

107 W. Canton St. Boston, Mass.

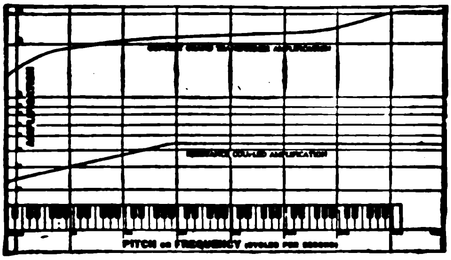
TWO WONDERS of the NIGHT!

AND THE
ARAGAIN RADIO RECEIVER
AUTOMETAL CORPORATION
NIAGARA FALLS

This Amazing Test
Proves Tone Troubles Ended

Exacting laboratory tests show that amazing new audio gives greatly superior tone curve. Remarkably uniform and even amplification of all tones at frequencies from 32 to 10,000 cycles.

Send Coupon



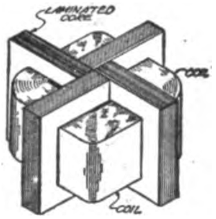
Note the smooth, even progression of the Concert Grand curve, revealing supreme uniformity of amplification, from lowest notes to highest in the musical scale.

One-piece drawn steel shell provides magnetic shielding. Finished in black crystalline lacquer and attractive in appearance.

A NEW audio frequency transformer has been perfected, the Erla Concert Grand. It is a new development of a principle which gives exceptional results, and remarkably uniform and even amplification of all tones over a broad range of frequencies.

Amazing improvement

Ordinary designs permit too much leakage to amplify properly at low frequencies. So we use the "quadriform type," heretofore unknown in radio work. In this design magnetic leakage is practically eliminated by providing twice as many paths for the magnetic field and by a better distribution of the core metal around the copper wire coils. Each of the four core units are complete magnetic circuits within themselves without breaks or joints to the main central core, and it will also be noticed that the central core section has a far greater area than conventional core types. The large area thus obtained reduces the effect of the direct "B" battery current on the pulsating voice currents and eliminates a cause of distortion common to transformers using smaller core sections.



Note the quadruple core surrounding the coil, forming an almost perfect path for the flux within the coil. The core is a special grade of laminated silicon steel that provides highest permeability and lowest hysteresis loss, with consequent maximum conductivity in the magnetic circuit of the transformer. Price $10.00. West of Rocky Mts., $10.50.

The Concert Grand saves you money too. Resistance coupling depends solely upon the tubes for amplification. Consequently they must be operated at maximum for efficiency, requiring more "A" battery current and higher plate voltage—135 to 150 volts. Filaments wear out more rapidly as result and battery life is more than cut in half. The higher initial cost of Concert Grand amplification is therefore saved many times over not only in improved performance but also in lowered upkeep cost.

Booklet sent FREE

Get the Audio Grand at your dealer's today. See what a tremendous difference it will make in your set. If you wish to return the coupon we will send you a new booklet giving the latest information on audio frequency amplification.

ERLA

ELECTRICAL RESEARCH LABORATORIES
Chicago, U. S. A.

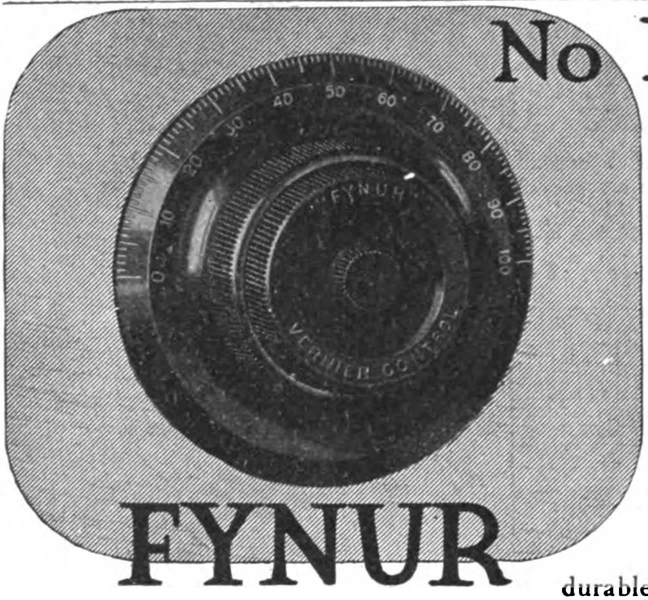
ELECTRICAL RESEARCH LABORATORIES,
2500 Cottage Grove Ave., Dept. 11-C, Chicago.

Send me information about the Erla Concert Grand Audio. Also latest developments on audio frequency amplification.

Name..

Address..

City.................. County.......... State.....



No Backlash *in this New Dial*

Used in Cockaday's new
LC-26 RECEIVER

The Fynur dial operates by traction (not gears) so that no backlash or lost motion is possible. Moreover, the dual control permits of a quick, general setting as well as the infinitely fine vernier adjustment. A quality dial for those who want the best—beautiful, mechanically perfect, and durable. So simple in construction that a child can take it apart and reassemble it. Manufactured by August Goertz & Co., Inc., 270-286 Morris Ave., Newark, N. J.

FYNUR

$3.50 VERNIER CONTROL

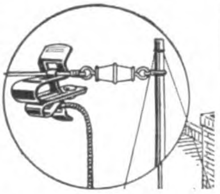
QUICK ACTION FAHNESTOCK

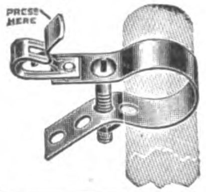
FAHNESTOCK CONNECTORS

Popular Wherever Radio is Used!

ANTENNA CONNECTOR

Eliminates splicing and soldering of wires. Snap larger connector over antenna wire; insert lead-in wire into smaller clip and a perfect connection is the result. Made of the finest quality Phosphor Bronze.



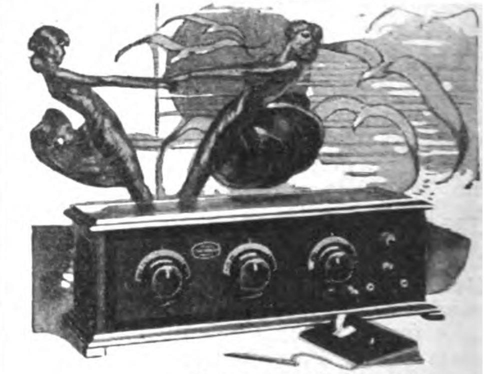


GROUND CLAMP

Eliminates soldering, easily attached.

Made from soft copper ⅝" wide with a phospher bronze spring binding post, also a screw and nut attached.

FAHNESTOCK ELECT. CO. L. I. CITY, N. Y.



1926 IMPROVED RADIO

$55.00

All the practical improvements developed during the season are incorporated in the new Arborphone Receiver. For clarity of reception and simplicity of tuning just compare the Arborphone with any other set, regardless of price. Arborphone owners can match performance with anyone.

Distance—coast to coast—is at your command. While not elaborate, the cabinet that houses this precision-built circuit is really beautiful in its simplicity of design.

For a thorough and consistent enjoyment of Radio's ever-improving programs Arborphone will satisfy completely those who demand simplified and perfected reception.

A most interesting catalog will be mailed on request. Dealers will gladly give you an Arborphone demonstration.

$60.00 in Rocky Mt. and Pacific Coast States

MACHINE SPECIALTY CO.
Ann Arbor Michigan

ARBORPHONE

Revolutionizing because of the application of new and fundamentally sound principles to the rectifier.

¶ B-eliminators or parts, specially designed for use with RAYTHEON tubes are made by these and other well-known manufacturers, and are now on sale at your dealer's:

Acme Apparatus Co., Cambridge, Mass.
All-American Radio Corp., Chicago, Ill.
Dongan Electric Mfg. Co., Detroit, Mich.
General Radio Co., Cambridge, Mass.
Jefferson Electric Mfg. Co., Chicago, Ill.
Mayolian Radio Mfg. Co., New York, N. Y.
Thordarson Electric Mfg. Co., Chicago, Ill.
Tobe Deutschmann Co., Boston, Mass.

RAYTHEON

Long Life $6 ***Economy***
No Filament ***Reserve Power***

RAYTHEON MANUFACTURING CO., Cambridge, Massachusetts
***Formerly* AMERICAN APPLIANCE CO.**

For EVERY Radio Set

A stunning piece of furniture that restores order in the room where you have your Radio! No more cluttered table-tops, nor litter of equipment under-foot.

Non-Vibrant Ceramic Horn

The clearest tone producer on the market. Made of special composition which defeats vibration.

No unsightly horn in evidence, either! This console has its own loudspeaker, in-built. It's out of sight, but with very apparent tonal superiorities. For it has the highest-developed type of unit. With horn built of special non-vibrating, extra-hard, ceramic material. Produces clear non-vibrant tone.

There's ample room for everything; space for *largest* A and B wet batteries—or battery eliminator—required for any home set; and for a big charging outfit, too.

Finished in mahogany, or walnut color. Dainty design of parqueterie on two front panels. Top, 38 in. x 18 in. Substantially built; the product of a 40-year old furniture maker.

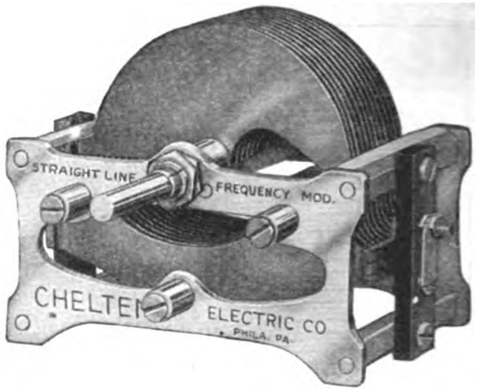
The price, forty dollars, is for the *complete* console and includes the loudspeaker horn and unit. Thousands of dealers are showing this artistic addition to home radio equipment.

Rear View—Set Hooked Up

Price, $40
West of Rocky Mts., $42.50

Windsor Furniture Co.

1430 Carroll Ave.
Chicago, Ill.



The Chelten
Straight-Line Frequency Condenser (Modified)

A real Condenser scientifically designed from practical operating standpoint. Dependable in every way. Spreads low wave stations. Provides uniform separation over tuning range. Standard frame—soldered brass plates.

Send for our booklet, "Straight-Line Frequency Tuning," an authoritative study on this vital subject. It's free.

CHELTEN ELECTRIC CO.
4859-65 Stenton Ave., - Philadelphia

Test your "A" Battery

easily—quickly

75c.

Ask your dealer—if he can't supply—or write us, enclosing price. No glass float to break, stick or get out of order.

with an

S.O.S.
Hydrometer

Small, fits easily under tables, or into Battery compartment of set. No figures to see—you do not have to withdraw Hydrometer from the battery to read. Saves all chances of spilling acid. The patented balls tell the story. Swim all THREE, charged fully. Sinks the WHITE, charge still right. Sinks the GREEN, charge is lean. Sinks the RED, charge is dead.

Chaslyn Balls standard equipment with leading battery manufacturers on glass cased batteries.

THE CHASLYN COMPANY
3845 Ravenswood Ave., Chicago

Earn $50 to $200 a Week *in* RADIO

You can! Hundreds of ambitious men are already earning thousands of dollars in this wonderful new industry—you, too, can get your share. Mail coupon below for Free Book which describes fully the amazing money making opportunities in Radio and tells how YOU can earn from $5,000 to over $10,000 a year.

THE astounding growth of Radio has created thousands of big money opportunities. Millions of dollars were spent during the past year on Radio, and thousands of young men are needed right now to meet the ever increasing demand of work.

Men are needed to build, sell and install Radio sets—to design, test, repair—as Radio engineers and executives—as operators at land stations and on ships traveling the world over—as operators at the hundreds of broadcasting stations. And these are just a few of the wonderful opportunities.

Easy to Learn Radio at Home in Spare Time

No matter if you know *nothing* about Radio now, you can quickly become a Radio Expert, by our marvelous new method of practical instruction—instruction which includes all the material for building the latest up-to-date Radio apparatus.

Scores of young men who have taken our course are already earning from $75 to $200 a week. Merle Wetzel of Chicago Heights, Ill., advanced from lineman to Radio Engineer, increasing his salary 100% *even while taking our course!* Emmet Welch, right after finishing his training, started earning $300 a month and expenses. Another graduate is now an operator of a broadcasting station PWX of Havana, Cuba, and earns $250 a month. Still another graduate, only 16 years old is averaging $70 a week in a Radio store.

PAY INCREASES OVER $100 A MONTH

I am averaging any where from $75 to $150 a month more than I was making before enrolling with you. I would not consider $10000 too much for the course.

(Signed) A. N. Long,
Greensburg, Pa.

DOUBLES SALARY

I can very easily make double the amount of money now than before I enrolled with you. Your course has benefited me approximately $3000 over and above what I would have earned had I not taken it.

T. Winder,
Grand Junction, Colo.

Wonderful Opportunities

Hardly a day goes by without our receiving urgent calls for our graduates. "We need the services of a competent Radio Engineer" — "We want men with executive ability in addition to Radio knowledge to become our local managers"—"We require the services of several resident demonstrators"—these are just a few small indications of the great variety of opportunities open to our graduates.

Take advantage of our practical training and the unusual conditions in Radio to step into a big paying position in this wonderful new field. Radio offers you more money than you probably ever dreamed possible—fascinating, easy work—a chance to travel and see the world if you care to or to take any one of the many Radio positions all around you at home. And Radio offers you a glorious future!

The National Radio Institute is America's Pioneer Radio Home Study School—established in 1914. Our course is an absolutely complete one now being offered which qualifies for a government first class commercial license. It trains you for *bigger* paying jobs in Radio.

Send for FREE RADIO BOOK

Learn more about this tremendous new field and its remarkable opportunities. Learn how you can quickly become a Radio Expert and make big money in Radio.

We have just prepared a new 48-page book which gives a thorough outline of the field of Radio—and describes our amazing, practical training in detail. This Free Book, "Rich Rewards in Radio," will be sent to you without the slightest obligation. Mail coupon for it *now!*

For a short time we are offering a reduced rate to those who enroll at once. Act promptly and save money. National Radio Institute, Dept. 32OB, Washington, D. C.

NATIONAL RADIO INSTITUTE
Dept. 32OB Washington, D. C.

Please send me without the slightest obligation your Free Book, "Rich Rewards in Radio," and full details of your special Free Employment Service. Please write plainly.

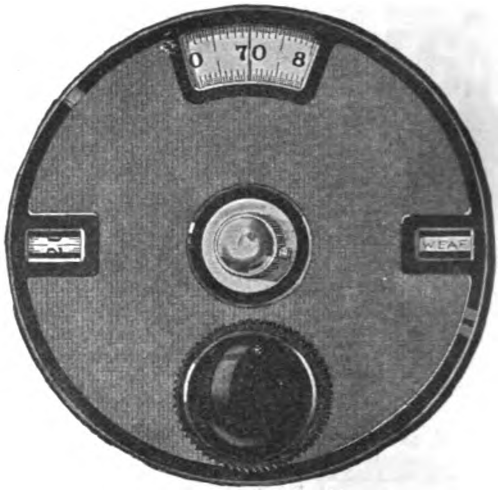
Name ....

Address ....

City .... State ....

The 1926 Model Tuning Control

On the new set you build, or on the favorite set you own now—put 1926 model dials! Today's conditions demand more accurate tuning control than old-type dials can give. Replace them with MAR-CO dials—handsome, responsive, supremely accurate—and keep a record of the settings in the two slots, right on the dial itself!



Martin-Copeland Company
Providence, Rhode Island

Nickel Plated	***Gold Plated***	***Provided with scales reading 0 to 100, or 100 to 0, as preferred***
$2.50	***$3.00***	

MAR-CO RADIO PRODUCTS **Vernier Dial**

ATTENTION DEALERS

Send for our 192 page catalog

RADIO SUPPLIES
SCHNEITTER'S
TRADE MARK
ST. JOSEPH, MO.

The finest and largest exclusive Radio Catalog in the United States

Schneitter Radio Company

Dept. G. St. Joseph, Missouri

GET GET GET

The

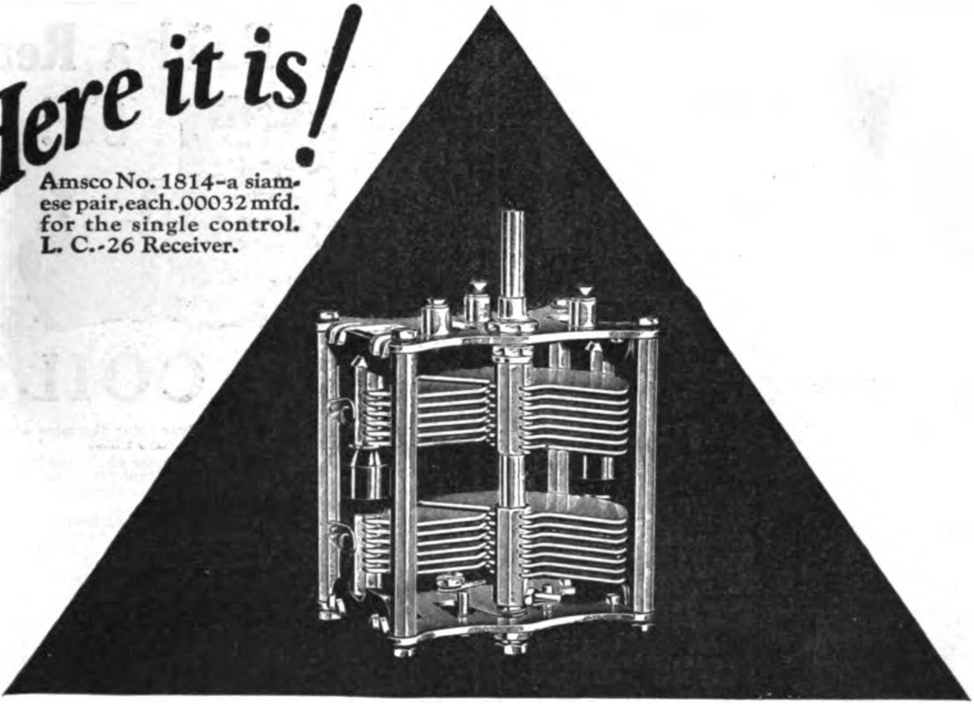
McLAUGHLIN ONE-CONTROL RECEIVER

You can easily build this marvelous new 8-tube single control receiver described in the October issue of Popular Radio. Simple in construction. When complete looks like a ready-built cabinet model. Receiving range up to 3,500 miles. Draws only 10 milliamperes plate current insuring longer life for "B" batteries. If ready-built this set would cost over $200 complete. Send your money-order for parts TODAY. Parts complete without cabinet,
$101.35

UN-I-DIAL RADIO CO.
35 Greenwood Ave., East Orange, N.J.

Here it is!

Amsco No. 1814-a siamese pair, each .00032 mfd. for the single control L. C.-26 Receiver.



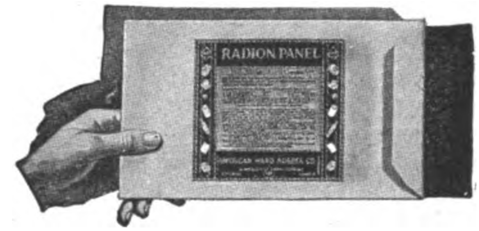
AMSCO 14 Plate Special

—for the single control radio receiver designed by L. M. Cockaday.

This condenser is exactly right for the "L. C.-26" circuit—each unit being electrically paired for straight line capacity and mechanically matched for synchronization. It is practically zero loss—with a minimum capacity that admits of tuning in the low wave bands you can't afford to miss. You will find it free of body capacity effects—and absolutely noiseless during adjustment.

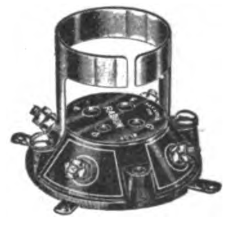
Ask your dealer for Amsco No. 1814 Special. If you can't get it, write us, at Dept. D

AMSCO
PRODUCTS
Broome and Lafayette Streets
New York City
Write for interesting booklet "The Heart of The Hook-up"



Radion Panels in black and Mahoganite come cut in standard sizes for all sets.

Be *sure* of lowest losses



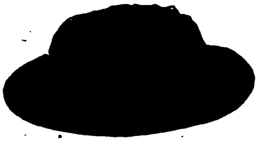
No. 2 Socket for new UX tubes with collar adapter for old type tubes. No. 4 same as No. 2, without collars, for new UX tubes exclusively.

RADION Panels are most effective in reducing surface leakage and leakage noises because they are moulded from the insulating material ***made to order for radio purposes exclusively.***

Tests after tests have proved that Radion insures lowest losses and highest efficiency. Radion Sockets, Dials, Insulators and Tubing have the same high-resistant characteristics, as Radion Panels. They embody the latest developments in radio. Ask your dealer to show you the complete line of Radion low-loss parts.

Send 10 cents for booklet, "Building Your Own Set"

AMERICAN HARD RUBBER COMPANY
Dept. B12, 11 Mercer Street, New York City
Chicago Office: Conway Building
Pacific Coast Agent: Goodyear Rubber Co. San Francisco, Portland



New No. 10 4-inch Radion Dial. Nine other styles in several sizes to meet all requirements.

RADION

The Supreme Insulation

Made to Order for Radio Purposes Exclusively

AMERICAN HARD RUBBER CO.
Dept. B12, 11 Mercer St., New York City.
Please send me your booklet for which I enclose 10 cents in stamps.

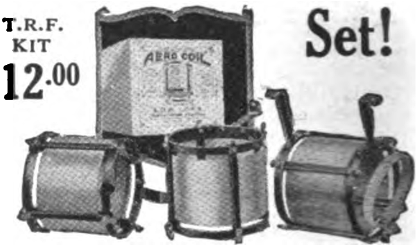
Name..

Address..

....

NOW! Build a Real Set!

T.R.F. KIT
$12.00



AERO COILS

Build a 5 Tube T. R. F. Receiver using the new Aero-Dyne Circuit and the new *matched* Aero Coils!

You will have a receiver, which because of the lower high frequency resistance and distributed capacity of its R. F. Transformers, will cut right through the strongest kind of local interference.

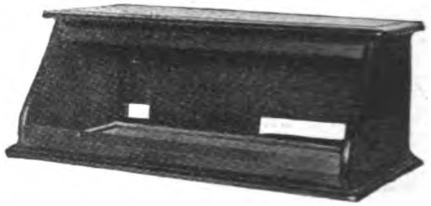
It is the patented construction of Aero Coils—their 95% air dielectric and their dopeless airspaced windings which make them capable of a degree of *selectivity* and of *volume* and *tone* far exceeding the commercial standard.

For any set there is a kit of Aero Coils. Buy them at your dealers. Full instructions are in every package. *Write for the free Aero Booklet.*

No. CT80	—3 Circuit Tuner	$ 8.00
No. RFR110	—R.F. Regenerative Kit	$11.00
No. WT40	—Wave Trap Unit	$ 4.00
No. O855	—Oscillator	$ 5.50
No. AX45	—Antennae Coupler	$ 4.50

AERO PRODUCTS, Inc.
217 No. Desplaines St. Chicago

For Quality **CORBETT'S CABINETS** **For Quality**



CABINET For LC-26 Receiver

Built exactly to specifications with full length piano hinge, lid stay, and splined mounting board.

List prices:

GENUINE AMERICAN WALNUT	$17.00
GENUINE MAHOGANY	17.00
MAHOGANY OR WALNUT FINISH	14.50

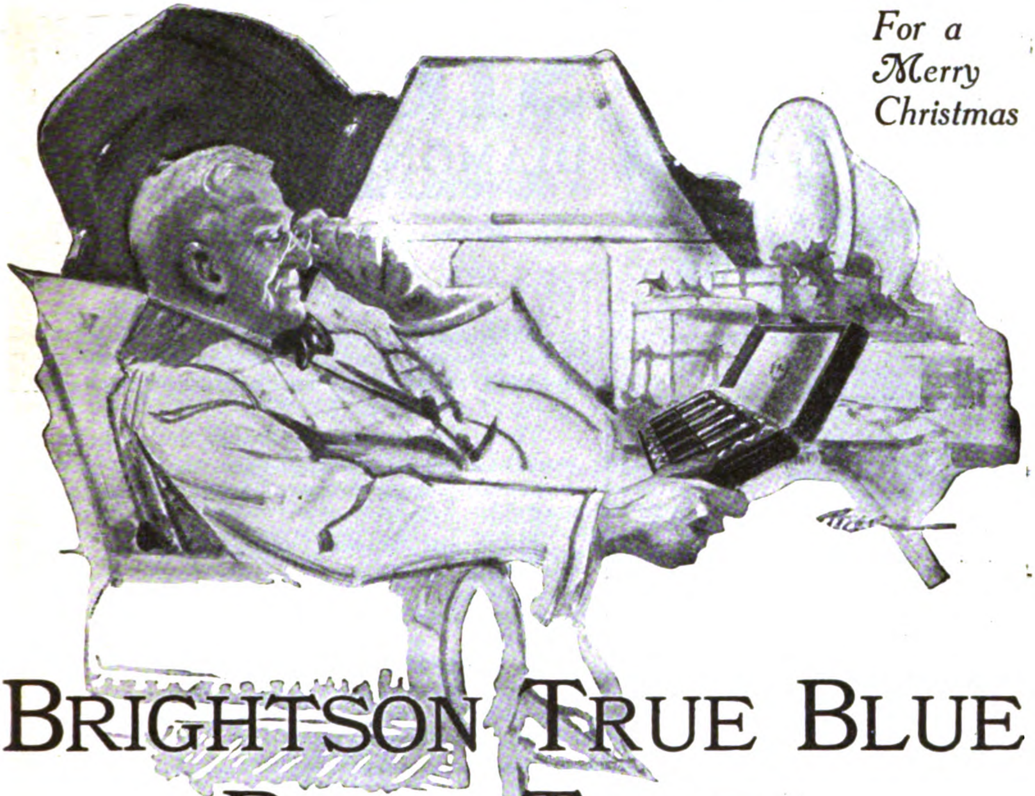
Shipping charges prepaid.

CORBETT'S CABINETS have been preferred for several years by quality set builders and are unquestionably superior in design and finish. They are backed by our guarantee to please you. Carefully hand rubbed piano finish. Well packed for shipment.

WRITE FOR CATALOG showing attractive models for all sizes of radio cabinets, consoles and tables.

Jobbers and Dealers write for discounts.

CORBETT CABINET MFG. COMPANY
St. Marys, Penna.



BRIGHTSON TRUE BLUE RADIO TUBES

INSURE the success of his Radio Christmas with a box of Brightson True Blue Radio Tubes, each one safely tucked away in a snug, handsome gift case containing one, three, five, six or eight tubes.

The perfect gift from the thoughtful giver because they are the finest money can buy, though inexpensive. Brightson True Blue Radio Tubes are true representatives of your true sentiment for the holidays.

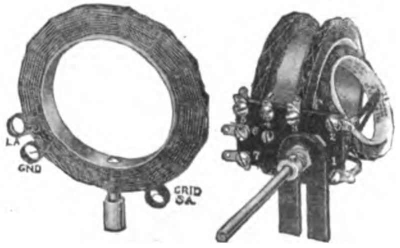
Brightson True Blue Tubes are unlike any other radio tube ever built—their very construction demands absolute uniformity in tone performance.

Each tube is interchangeable—non-microphonic—serving perfectly as detector, oscillator, or radio and audio frequency amplifier in any circuit. Insist upon Brightson True Blue Radio Tubes. Price $3.50 each.

BRIGHTSON LABORATORIES, Inc.
WALDORF-ASTORIA HOTEL, 16 WEST 34th STREET, NEW YORK CITY

PHILADELPHIA OFFICE:
50 N. Eleventh St.
Philadelphia, Pa.

BOSTON OFFICE:
260 Park Park Square Bldg.
Boston, Mass.



Sickles Coil Set No. 24 for Browning-Drake Circuit. **Price $7.50.**

COIL PRICES

No. 18A	Roberts Circuit	$ 8.00 set
No. 24	Browning-Drake	7.50 set
No. 20	Craig Circuit	4.50 set
No. 19	Acme Reflex	4.50 set
No. 8	Knockout Reflex	4.00 set
No. 21	Hoyt Circuit	10.00 set

SICKLES

DIAMOND-WEAVE COILS

(Trade Mark registered Aug. 4, 1925)

For Browning-Drake, Roberts, Craig, and Hoyt Circuits

(Patented Aug. 21, 1923)

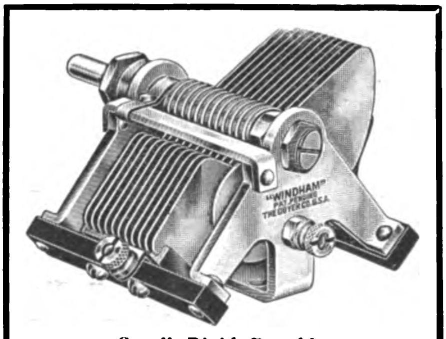
Compactness of form, rigidity of construction, and the supremely efficient Diamond-Weave method of winding are well-known characteristics of Sickles Coils.

These refinements of design and construction result in low distributed capacity, low dielectric losses and large range of frequency with small variable capacity.

There are Sickles Diamond-Weave Coils for all leading circuits.

Send for descriptive catalog

The F. W. Sickles Co.
134 Union Street
SPRINGFIELD, MASS.



Small, Rigid, Durable

The New "Windham"

Station Separating
CONDENSER

A NEW { STANDARD OF EXCELLENCE
MEASURE OF WORKMANSHIP
DEGREE OF SATISFACTION

For Those Who Are Seeking Better Things in Radio

Let us tell you more about this superior condenser that sells at a price within the reach of all

Desirable territory may be had, if you write today

THE GOYER COMPANY
Willimantic, Conn., U. S. A.

Get This Big Western Radio Catalog

NEW
1925-1926
EDITION

DEALERS, send for our big live catalog. Contains nationally advertised high quality sets, kits and parts. Use your letterhead.

Western Radio Co.
134 W. Lake St. Chicago

Everybody Wants Single Dial Control

But few radio makers provide it

Why?

Actual Wave Length GLOWS from Illuminated Disc—No Scale Necessary

SINGLE dial control is an immense advantage in tuning. It is not only utterly simple; it enables the merest amateur to tune as accurately as an expert. You do not have to grope around adjusting dials. You IMMEDIATELY turn one control to the wave length desired. You can do that by ear, if you like.

What is the handicap?

Why do so few makers offer a single dial? Because most circuits are too complicated to permit of it. You have to drive too many horses. It is evident that you cannot tune with a single dial unless the circuits are *electrically* equal, and they cannot be electrically equal if there is any coupling of stray energy between them. It matters not whether such stray energy is "trapped" by extra condensers or other devices. The inequalities are still there and prevent accurate single dial tuning.

That is why you see single dial sets equipped with verniers and auxiliary adjusters. These are needed to complete or refine the tuning. That operation is as complicated as using three dials.

The secret of success

Pfanstiehl last year laid the foundation for a perfect single dial control by discovering how to prevent stray energy at its source, how to keep the radio stream in its forward path without the use of auxiliary devices. That was the secret also of his OVERTONE reproduction and the matchless tone which results. There is no stray energy to mar the delicate vibrations which make overtones. Voice and music are reproduced exactly as transmitted. And his single dial works with the utmost precision; enables anybody to tune as accurately as an expert. It is *fundamentally* sound.

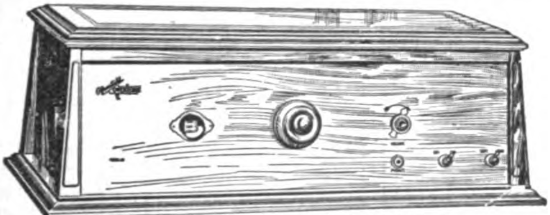
An Exclusive Dealer Franchise

The Pfanstiehl line is sold through exclusive dealers who are thus protected against unfair competition and price cutting. Whatever good-will the dealer builds up for Pfanstiehl is his own. He enjoys a liberal profit and is expected in return to push the line aggressively with the cooperation of the maker.

For further details, address

PFANSTIEHL RADIO COMPANY
11 South La Salle Street, Chicago, Illinois

Prices West of the Rockies Slightly Higher



MODEL 10—Overtone Single-dial 6-Tube Receiving Set. Price $155.00 (less accessories)

MODEL 10C—A complete 6-Tube Single-dial Console Overtone Receiver with Overtone Speaker, Control Board, Battery Charger and Compartments for Battery built in. Price $450.00 (less tubes and batteries).

MODEL 10S—Overtone Single-dial 6-Tube Receiving Set with demountable Console Stand. Overtone Speaker built in. Price $200.00 (less tubes and batteries).

MODEL 8—A low priced 2-Dial 5-Tube Receiving Set, Pfanstiehl quality throughout. Price $85.00 (less accessories)

MODEL 8C—Two-dial 5-Tube Receiving Set, demountable from console stand, permitting use on floor or table. Overtone Speaker built in. Price $135.00 (less tubes and batteries).

Pfanstiehl

"OVERTONE" RECEIVER

Perfectly Reproducing the Overtones

Christmas on the Air!

Are Your Tubes in Shape?

At Christmas Tide! Listen to sweeter "Christmas Carols"—clearer chimes and more celestial music broadcast by the great cathedral choirs throughout the land.

A Rhamstine* TUBE BOOSTER

Rhamstine Tube Booster Only $6

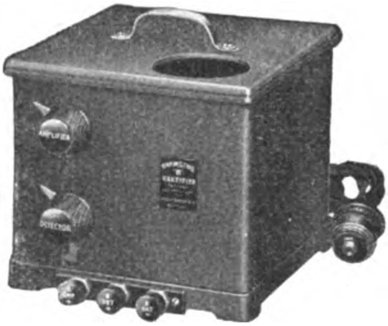
will renew your old tubes with all the pep and freshness of new ones. Just put them in the socket and turn on the current—do it once a month—it will treble the life of your tubes and give you better distance, volume, and a tone as clear as a bell at all times. It will pay for itself in a few days.

Works on any alternating current 110-120 volts, 50-133 cycles. It matters not whether you use 201-A or 199 Type Tubes.

Send no money—check the coupon below—pay on delivery.

"B" RECTIFIER (Eliminates "B" Battery)

Rhamstine* "B" Rectifier Only $25.00



(tube not included)

Eliminates all your "B" Battery troubles such as recharging. dead cells, and chemical action. A Rhamstine* "B" Rectifier will more than take the place of a "B" Battery—it will give a continuous and uniform current year in and year out with absolutely no trouble at all. Small, compact, good looking, endorsed by the leading radio manufacturers, and reasonably priced. You should have one.

Send no money—just check the coupon

Tube Boosters are Trade Boosters. DEALERS write for our attractive proposition.

Mail the Coupon Today

J. THOS. RHAMSTINE* (12)
Woodbridge at Beaubien,
Detroit, Mich.
Please send me
☐ Rhamstine* Tube Booster at $6
☐ Rhamstine* "B" Rectifier at $25
by express C. O. D. subject to inspection. If I am not entirely satisfied with the "B" Rectifier I will return it to you in five days and receive a refund of the full purchase price

Name . . . .

Address . . . .

J. THOS. RHAMSTINE*
Radio and Electrical Products
Woodbridge at Beaubien, Detroit, Mich.

A *new* Binding Post

Designed specially for radio use and improved to keep pace with the progress of the Radio Industry

G-K *Spring Cap* Binding Post

Highly Polished Nickel Plated Post—

Genuine Bakelite Knob.

15c EACH

In its present form our Binding Post—fully protected by Patents—is the result of careful study of conditions by our Engineers in cooperation with Set Manufacturers and individual builders of Sets.

Spring Contact and Release—Shaft marking gives exact location of hole through which contact wire is inserted and eliminates fishing with wire—easily manipulated.

Bakelite Knob cannot come off
Plainly marked usual engravings
Approved by leading Radio Engineers
Nationally advertised

GANIO KRAMER CO., Inc.
238-240 West 53rd Street, N. Y. City
Manufacturers of "*Kant Blo*" Battery Switch

BLANDIN TRIPLE A

You'll Like This Duplex

One cabinet—

Any panel size, 7x26, 7x24, 7x21 or 7x18". Depth 10". Room for all dry batteries.

Either straight or sloping panel—grooves, no screws.

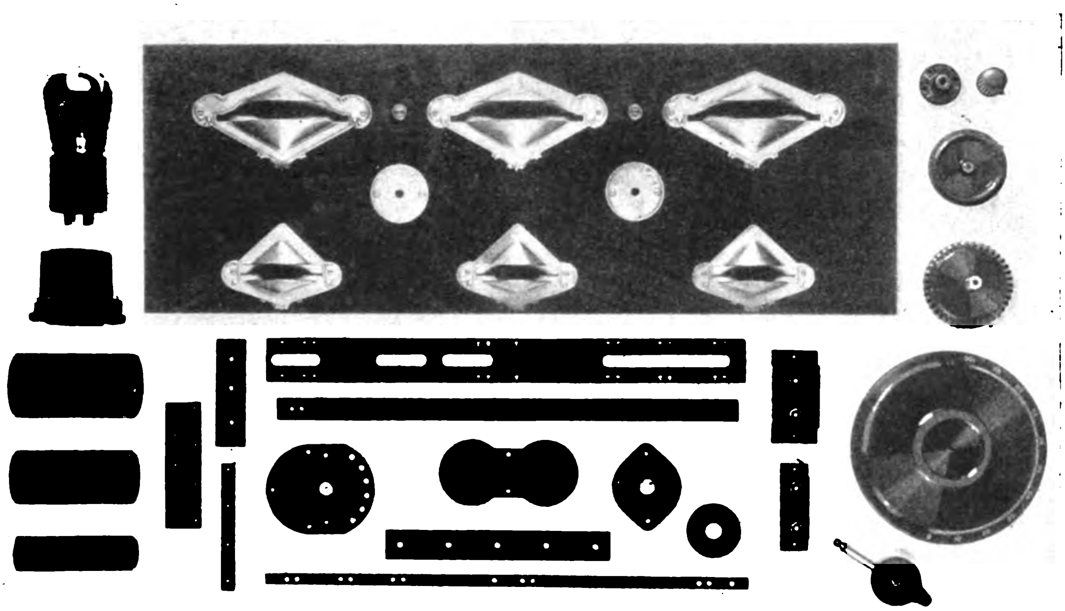
Solid mahogany. Latest lacquer hand-rubbed finish. Entire lid raises. Full length piano hinge. Folding lid supports. Felt covered feet. Extra ½" mounting board.

Write for Duplex and Console illustrated price lists. Dealers, write your jobber.

The new Blandin Console is ready for you.

Blandin Radio Cabinets

Built by
BLANDIN
1500-16th St.
Racine, Wis.



Imagine a Radio Set stripped of these parts

What a useless collection of wood, wire and metal it would be. Realizing that the parts and accessories shown here are wholly or partly of Bakelite, gives you a vivid picture of its importance to Radio.

Today Bakelite is used in a greater variety of radio parts than ever before—and the number grows constantly. This dominance of Bakelite in radio reflects the experience and the opinions of radio manufacturers, great and small.

Radio set and parts manufacturers have every facility for testing all insulation materials and over 95% have standardized on Bakelite. This indicates how really important it is for you to make sure that the set or parts that you buy are Bakelite insulated.

Write for Booklet 28

BAKELITE CORPORATION
247 Park Avenue, New York, N. Y.
Chicago Office: 636 West 22d Street

Bakelite is an exclusive trade mark and can be used only on products made from materials manufactured by the Bakelite Corporation. It is the only material which may bear this famous mark of excellence

BAKELITE

REG. U. S. PAT. OFF.

BAKELITE is the registered trade mark for the phenol resin product manufactured under patents owned by the Bakelite Corporation.

THE MATERIAL OF A THOUSAND USES

DOUBLETOROID COILS
Patented March 31, 1925
Price $2.75

Do you desire greater volume on your lower wavelengths, and increased selectivity? Then we recommend Doubletoroids that can be mounted anywhere, that do not form miniature loop aerials, and that have no external fields.

Outstanding Features of the Doubletoroids

Primary and secondary coils are true toroids.

The magnetic path is shorter.

They are the most compact.

Write for booklet showing the "hook-up," and embodying a letter from Professor J. H. Morecroft of Columbia University, a recognized authority on toroid coils.

Patented June 16, 1925

It's Variable Price 85c.

The Nonoise Gridleak improves reception because it can be adjusted for every station. Fits standard brackets. Absolutely noiseless. At all dealers and in the better sets.

NONOISE GRIDLEAK

RADIO FOUNDATION, INC.

25 West Broadway **New York**

DEALERS: ***Some territories still open. Write.***

Where you see these signs ⊣⊢ in circuits—use ⊐⊢

Potter BY-PASS Condensers

They prevent "B" voltage fluctuation
—Allow undistorted amplification
—Make possible full bass tones at all frequencies
—Improve reception with "B" Supply Units
—Essential for building the new Autoformer Amplifier

As easily attached as the "B" battery

Made in 1/10, ¼, ½, 1, 2, 3 and 4 Microfarad sizes

At your Dealer's

POTTER MANUFACTURING COMPANY
North Chicago, Illinois

The Remo Trumpet

(Concert Type)

Acknowledges No Superior!

Perfect reproduction with volume, without distortion. The secret of beautiful tone lies in this loudspeaker. You must hear it to be convinced. Your dealer will arrange this. Send us his name.

Price $25.00

The Remola Concert Cabinet

The same tone quality as the Remo Trumpet, but even sweeter. A mahogany cabinet of just the right size.

Price $25.00

The Remo Corp.
Meriden, Conn.

Send for this RADIO BOOK FREE

RADIO
The Heart of the Home
Complete Catalog of radio sets, radio kits, parts and equipment. Also valuable information and instructions on radio.
Save ⅓ to ½
SATISFACTION GUARANTEED
RANDOLPH RADIO CORP
155-159 N. UNION AVE. CHICAGO, ILL.
LARGEST EXCLUSIVE RADIO MAIL ORDER HOUSE IN THE WORLD

1926 Catalog of RADIO BARGAINS Save ⅓ to ½

The World's Largest Exclusive Radio Mail Order House Will Send You This Wonderful Book FREE

64 illustrated pages containing thousands of bargains in radio sets, semi-finished sets and radio kits of all styles, sizes and approved circuits. **5-tube sets as low as $29.50.** Beautiful models of the very latest designs and types. Elaborate console models with loud speakers built right in cabinets of genuine mahogany and walnut. **All sets guaranteed.** Coast to coast receiving range. Also contains everything in radio supplies, including batteries, chargers, loud speakers, transformers, condensers, rheostats and any other parts you may want for improving your set or building a new one. Guaranteed saving to you of ⅓ to ½.

AMERICAN RADYNOLA 5 TUBE SET

$29.50

The Biggest 5-Tube Value on the Market

Positively the world's greatest 5-tube radio bargains. **Regular $75.00 value.** Our large quantity production enables us to sell this set for **only $29.50,** fully built and wired in beautiful mahogany cabinet of latest design with sloping Bakelite panel of Satin finish, handsomely etched and engraved as illustrated. Constructed of the finest low-loss condensers, coils and sockets. Bakelite baseboard panel and dials. **Price for set only. $29.50** Transportation charges extra, shipping weight 25 lbs.

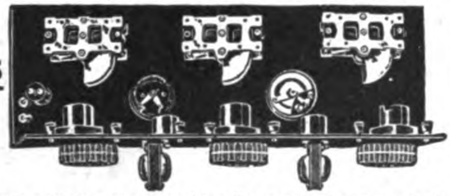
This set with all accessories, including the famous **American Bell loud speaker** with adjustable unit, 2-45 volt "B" batteries, one guaranteed 100 Ampere Hour, storage "A" battery, cable for battery connection, 5-201A tubes, Aerial and ground equipment, and everything complete ready to set up and operate. Nothing else to buy. **Price $59.75** Transportation charges extra. Shipping weight 100 lbs.

Order Direct from This Page! Save About One-Half!

Order direct from this page. Save ⅓ to ½. Our guarantee protects you. Money cheerfully refunded if you are not satisfied. **Write your order and prices plainly.** Send post office money order or bank draft for full amount to insure safety. Refer to any bank or commercial agency regarding our reliability.

SEMI-FINISHED 5-TUBE RADIO FREQUENCY SET

$18.75



This special offer is astounding the radio world. **Coast to coast reception on loud speaker.** Low loss condensers and sockets. Highest quality transformers. Bakelite rheostats. All wiring concealed under Bakelite baseboard. 7x18 panel—fits into any standard 7x18 cabinet. Complete instructions for operating. **Guaranteed saving to you of $50.00. Price of set all mounted, $18.75.** Cabinet of same model as American Radynola pictured above $5.65 extra.

You must have our catalog no matter what set or kit you want. Our line is complete and includes all popular sets, such as Superheterodyne, Neutrodyne, Ultradyne, Reinartz, Regenerative, Radio Frequency, Browning-Drake, Super-Heterodyne Reflex and all other latest circuits. Kits, sets and parts manufactured by all well known manufacturers such as Frost, Howard, Baldwin, Brandes, Western Electric, Columbia and others.

Our semi-finished sets come with all parts mounted on panel and baseboard ready for wiring. Do not fail to send for our catalog. Remember—we are the largest exclusive radio mail order dealers in the world and carry the best of everything in radio. We save you ⅓ to ½ on the following kits. Detailed descriptions appear in our catalog.

SEMI-FINISHED 8-TUBE SUPER-HETERODYNE

$43.75

Complete Parts for Best 45 Kilocycle Super-Heterodyne Genuine Remler Parts $49.50

World's Famous 8-tube superheterodyne. Fully mounted on panel and baseboard. Comes **completely assembled** ready to wire and operate. We have testimonials from thousands of builders of this set. Some have received foreign stations on loop aerial. Unsurpassed in volume and tone quality. Low-loss straight line frequency condensers, vernier dials, finest quality rheostats. Matched Columbia long waved transformers. Requires only three screws for attaching panel and baseboard and set is ready to operate. 7 x 30 panel. **Price of set only $43.75.**

Requires following accessories to complete this set: 7x30 cabinet, 8-201A tubes for storage battery operation or No. 199 tubes for dry cell operation. 100 Ampere hour storage battery, 2-45V "B" batteries, loud speaker, center tapped loop aerial. All these items are listed in our catalog **at a tremendous saving.**

Catalog includes list of broadcasting stations, general radio information and facts about our free service division. Write for it today.

NEUTRODYNE Genuine licensed Neutrodyne kit of parts, come fully assembled on the panel and baseboard with complete instructions, ready to wire. Price, **$29.75**

COCKADAY 3-tube Cockaday kit of parts, fully assembled on panel and baseboard, ready to wire Price. **$15.85**

FOUR TUBE BROWNING DRAKE and also PRESSLEY and REMLER SUPER-HETERODYNE At Bargain Prices.

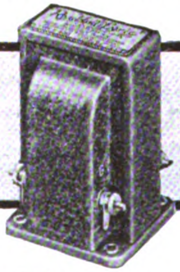
Genuine Parts for Cockaday Resistance Coupled and 5-tube set at prices that will astound you. Also complete parts for AC Kit.

RANDOLPH RADIO CORPORATION

159 N. Union Ave. Dept. 193 Chicago, Illinois

Carol

Far out over hill and valley — into the homes of rich and poor alike — come the waves that carry the glad tidings of the Savior's birth. Little does it matter whether the set is of new mahogany and gold or of humble cardboard coils. *Tonal beauty* in the amplifier is the one indispensable need for the real joy of radio. Happy indeed is the owner of Rauland-Lyric!



A New Gift for Every Radio Listener

Two Rauland-Lyrics in this beautiful holiday box (fully sufficient for any radio set). See it at your dealer's!

ALL-AMERICAN RADIO CORP., Chicago

Rauland-Lyric
AN
ALL-AMERICAN
TRADE MARK
TRANSFORMER
The Choice of Noted Music Critics

for radio dealers
—our big new catalog; fully illustrates the best in radio. Write on letterhead for copy — ask for B1005.

We Ship Fast

Wakem & McLaughlin, Inc.
225 E. ILLINOIS STREET :-: CHICAGO, ILL.

Oh boy
KESTER
Rosin Core
Radio SOLDER
Sure is Safe and Simple
APPROVED BY RADIO ENGINEERS
A GENUINE SOLDER
CHICAGO SOLDER COMPANY
4221 Wrightwood Av., Chicago, U.S.A.
Originators and World's Largest Manufacturers of Self Fluxing Solder
YOUR DEALER CAN SUPPLY YOU

Thorola Islodyne (5-tube) Walnut Cabinet, Model 55	$100
In Thorocco, Model 50	$85
In Mahogany, Model 51	$85
Thorola Islodyne Console, Model 52	$225
Thorola Golden Audio Reproducing Transformers	$4.50
Thorola Low-Loss Doughnut Coils Set of 3	$12
Per Coil	$4
Thorola Low-Loss Straight Line Frequency Condensers	$5.50 and $6

You and Reichmann

Sales demand or mere popular enthusiasm for something new has never swerved Reichmann Company from building only the kind of radio that *should* be owned by anybody.

You cannot go to a radio show or talk to radio experts without hearing of what Reichmann has done in the Thorola Islodyne. There are very exact reasons why it is the positively selective, precise-toned, uniformly produced set with correspondingly superior volume and distance. This is due not merely to the much-acclaimed theories of toroid coils, but to the unique low-loss structural properties exclusive to Thorola Low-Loss Doughnut Coils.

Consider also the indirect effects! By eliminating coil vexations and variables it was possible to attack factors which had been overshadowed by the coils. New control was gained over the elements of reception and of production!

New standards of radio entertainment have become possible. Everywhere, this is massing preference behind Thorola Islodyne receivers. They are the advance of the year in broadcast reception, with mathematically exact reasons for every claim. The proof is equally convincing from the scientific standpoint, or "by ear." The very proportions of Thorola cabinets bespeak new internal arrangement. Go and see Thorola at the show. Go and hear Thorola Islodyne at the nearest good radio store. It is the one way to make sure of owning radio that will stay far in advance.

REICHMANN COMPANY, 1725-39 West 74th St., CHICAGO

THOROLA SPEAKERS

With vital technical refinements including the self-harmonizing feature, Thorola Loud Speakers increase their margin of leadership. The new Bakelite bell is the largest Bakelite form ever produced. The ingenious throat construction, and identifying gold throat-band lend inspiring grace and rugged strength.

Thorola No. 4, $25 Thorola Junior, $15

Thorola Islodyne

BEAUTY AND TONE! TWENTY-FIVE DOLLARS

Music Mirror is a beautiful and clever adornment to any radio set. Its tones are very sweet and clear. Built entirely of genuine, solid mahogany with heavy plate glass mirror.

SEND US $25 IF YOUR DEALER CANNOT SUPPLY YOU. SOLD ON FIVE DAY TRIAL

IRVIN I. AARON

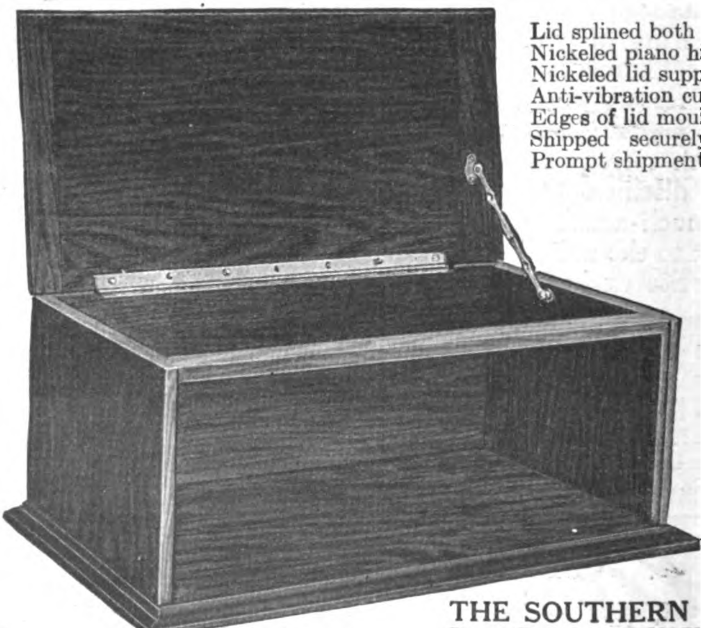
SALES OFFICE

36 SOUTH STATE STREET CHICAGO, U. S. A.

Music Mirror

"All That the Name Implies"

A RADIO CABINET OF BEAUTY AND ELEGANCE DIRECT TO YOU AT LOWEST COST



Lid splined both ends to prevent warping.
Nickeled piano hinge.
Nickeled lid support of artistic design.
Anti-vibration cushion feet (not visible in cut).
Edges of lid moulded to match bottom.
Shipped securely packed in strong carton.
Prompt shipment.

	Hardwood, Rubbed Mahogany Finish	Solid Black American Walnut
7 x 18 x 7½ *or* 10 in. deep	$3.50	$5.00
7 x 24 x 7½ *or* 10 in. deep	4.00	5.50
7 x 26 x 7½ *or* 10 in. deep	4.75	6.25
7 x 28 x 7½ *or* 10 in. deep	5.50	7.00
7 x 30 x 7½ *or* 10 in. deep	6.00	8.00
7 x 21 x 10 in. deep	3.75	5.25

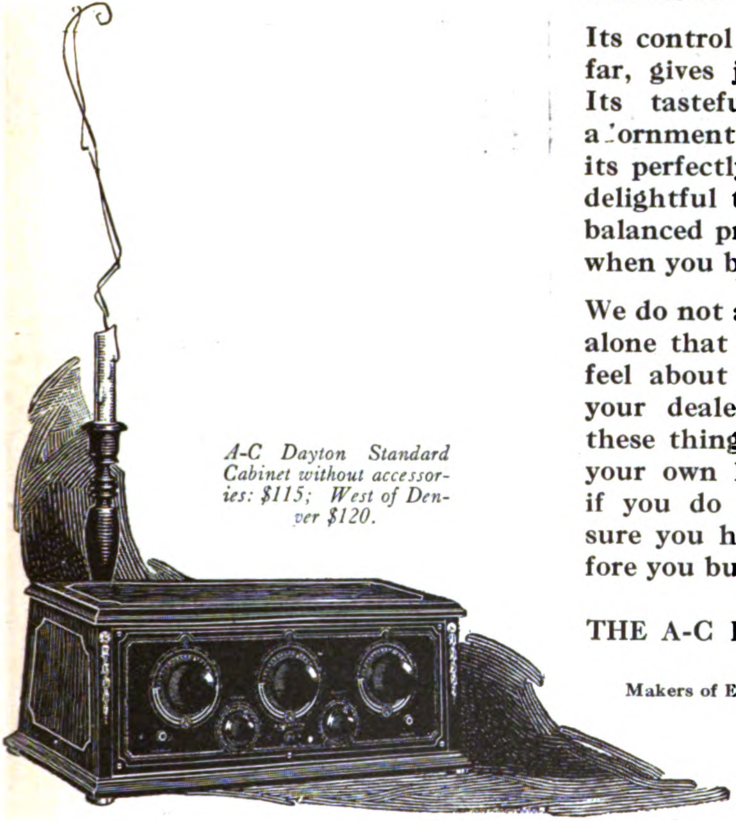
CASH WITH ORDER or C. O. D. if ¼ of price is sent with order. Prices F. O. B. Hickory, N. C. Order express shipment, often cheaper than mail and much safer from damage.

FREE WITH EACH CABINET a glued-up stock non-warping ½-inch BASEBOARD.

Free Catalogue.

THE SOUTHERN TOY COMPANY, INC.
Dept. P. HICKORY, NORTH CAROLINA

A Set to be Proud of—
a Set to Enjoy—



A-C Dayton Standard Cabinet without accessories: $115; West of Denver $120.

Whether it is matching the DX records of a distance loving neighbor or satisfying the critical ear of a skeptical opera lover, the A-C Dayton is forever giving you new reasons to be glad that you chose it.

Its control of all stations, near and far, gives just cause for boasting. Its tasteful design makes it an adornment to your home. And its perfectly modulated volume and delightful tone make you glad you balanced price against performance when you bought.

We do not ask you to take our word alone that this is the way you will feel about your A-C Dayton. See your dealer and have him prove these things by a demonstration in your own home. Write us direct, if you do not know him—but be sure you hear the A-C Dayton before you buy.

THE A-C ELECTRICAL MFG. CO.
Dayton, Ohio
Makers of Electrical Devices for More Than Twenty Years

A-C DAYTON
RADIO

for the man who believes his own ears

There's economy and satisfaction in these Valley Radio units

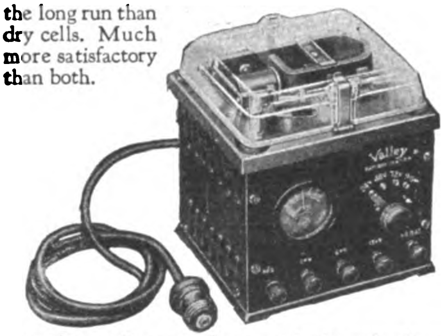
You will find both economy and satisfaction in the use of the Valley B-Eliminator and the Valley Battery Charger.

Economy in the B-Eliminator because it stops forever the expense of buying new B batteries. . .

Economy in the charger because it recharges your own storage battery at home overnight at one-tenth the cost of service station charging. . .

And satisfaction in both because, by using them, you need never miss a program on account of low or worn-out batteries.

The Valley B-Eliminator operates from any ordinary light socket and provides a steady, noiseless flow of B current *at a constant voltage all the time.* For receiving sets of from one to eight tubes. Costs less at the start than wet B batteries. Costs less in the long run than dry cells. Much more satisfactory than both.



The Valley Battery Charger is the only charger needed for all radio storage batteries. Its correct 6-ampere charging rate makes overnight charging a possibility.

Most radio dealers handle the Valley B-Eliminator and Valley Charger. Any of them will be glad to show you these units and explain their advantages.

Radio Division
Valley Electric Co. St. Louis, U. S. A.
Branches in Principal Cities

Valley Electric

ANNOUNCING
THE New Type B
NATIONAL Velvet Vernier DIAL
the dial with the variable ratio

This Dial will please you because of its intrinsic beauty—ease of mounting (fits any condenser)—its velvety smoothness—no back lash—and because it is the only dial that enables you to *pick your own ratio.* These are exclusive features possessed by the new National. *Write for Bulletin 107 P. R.*

NATIONAL CO., Inc.
W. A. READY, President
110 Brookline St., CAMBRIDGE, MASS.

STANDARD TYPES **$2.50**

CLEARTRON

GUARANTEED RADIO TUBES

Cleartron is the only radio tube sold with an Iron-Clad Guarantee of perfect service or instant replacement. Use them for better tone, more volume and greater distance.

At All Reliable Dealers

Write for Free six page tube folder.

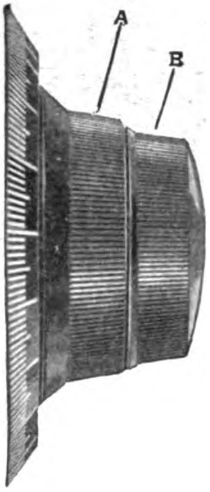
C-T 101A. The original Hi-Mu Tube for Resistance-Coupled Amplifiers. Price $3.00.

CLEARTRON VACUUM TUBE CO.
28 West 44th St. New York City
Factories:
West New York, N. J. U.S.A. Birmingham, Eng.

FOR BETTER RECEPTION

Greater Selectivity More Stations

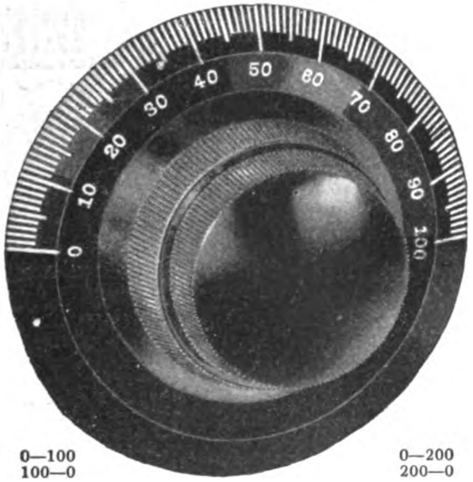
"Aligns Rite—Holds Tite"



Four-inch dial—with 2⅝" tapered Vernier Knob (A) and 2" tapered Knob (B) for ordinary tuning.

Kurz-Kasch Aristocrat E-Z Toon dials increase the selectivity of your set, making "tuning in" of stations easier and thereby giving you more stations. E-Z-Toon dials permit you to tune out "locals" and bring in distant stations clear and loud.

No set is complete without E-Z-Toon dials. There are so many stations crowding into your set that unless you have the greatest selectivity you are unable to enjoy any one. Close selectivity gives clearer tone. You do not have "mushy" reception. Especially good on short wave sets (40 to 200 meters).



Kurz-Kasch patented split bushing for mounting.

Fits any length of shaft.

No cogs or gears—no back lash or lost motion.

Simply and quickly installed. Take off old dial—slip on Aristocrat E-Z-Toon and tighen on shaft. No drilling of panel or other changes in set required.

Rigid construction — nothing to break, wear out, or get out of order.

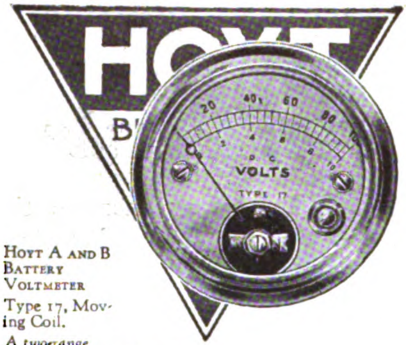
0—100
100—0
$2.25

0—200
200—0
$2.35

Write for illustrated literature on complete Kurz-Kasch line, Dials, Knobs, Sockets, Potentiometers, Rheostats, etc.

Manufactured by
THE KURZ—KASCH COMPANY
Largest Exclusive Moulders of Bakelite
Factory & Main Office Dayton, Ohio.

Don't Blame the Set



Hoyt A and B Battery Voltmeter

Type 17, Moving Coil.

A two-range voltmeter with pushbutton in cover glass.

WHEN your radio set begins to act queerly and symptoms of hoarseness appear in your loud speaker, when distance dies and locals lose their accustomed appeal, don't blame the set — first. The best car in the world won't run on flat tires. You probably have a tire gauge to tell you the air pressure in your tires. Hoyt meters in your radio set will prevent the flat tires of radio — discharged batteries, loose connections, and poor tubes. Without meters, a radio set in trouble is anyone's guess. With meters, you can diagnose the trouble. Usually you can prevent it. Don't blame the set — use Hoyt meters and place the blame where it belongs.

Send for catalogue describing the entire line of Hoyt Radio Meters—an instrument for every use.

Burton-Rogers Company
26 Brighton Ave. - - Boston, Mass.

National Distributors

You Save 50%

World Radio "A" and Auto Batteries are famous for their guaranteed quality and service. Backed by years of successful manufacture and thousands of satisfied users. Equipped with *Solid Rubber Case*, an insurance against acid and leakage. You save 50 per cent.

Approved!

Listed as Standard by Leading Authorities including Radio News Laboratories, Popular Science Institute of Standards, Popular Radio Laboratories, Radio Broadcast Laboratories, Radio in the Home and Lefax, Inc.

Radio Station WSBC

Set your Radio Dials at 210 meters for the new 1000 watt World Storage Battery Sta., WSBC, Chicago, Ill. Watch for announcements.

2-Year Guarantee Bond in Writing

WORLD Battery owners "tell their friends." That's our best proof of performance. Send your order in today.

Solid Rubber Case Radio Batteries

6-volt, 100 Amperes	**$11.25**
6-volt, 120 Amperes	**13.25**
6-volt, 140 Amperes	**14.00**

Solid Rubber Case Auto Batteries

6-volt, 11-plate	**$11.25**
6-volt, 13-plate	**13.25**
12-volt, 7-plate	**16.00**

SEND NO MONEY

Just state battery wanted and we will ship day order is received, by Express, C. O. D., subject to your examination on arrival. **Extra Offer:** 5 per cent discount for cash in full with order. Buy **now** and get a guaranteed battery at 50 per cent saving to you.

WORLD BATTERY COMPANY
Dept. 3 1219 So. Wabash Ave., Chicago, Ill.

FREE two unusual RADIO CATALOGS

FOR "FANS"

OUR new 64-page Radio Catalog including all the best and latest Kits, Parts and Accessories for broadcast receiving sets. Lowest prices in the country!

FOR "HAMS"

NEW 32-page booklet of army and navy transmitting apparatus and miscellaneous specials for "hams" such as W. E. Choke Coils, Generators, Resistance Boxes, etc.

More than 1,000,000 fans and hams make our store their headquarters—get these books and find out why

Write for either or both

509
South
State
Street

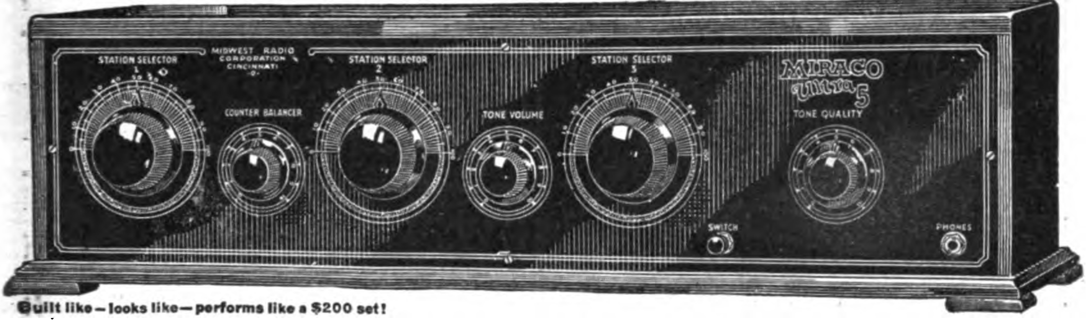
RADIO CENTER NOT MERELY A STORE—BUT A CHICAGO SALVAGE STOCK STORES NOT MERELY A STORE—BUT A RADIO CENTER

Dept.
P R 6
Chicago
Ill.

"It's a real musical instrument-clear as a crystal"—"Unsurpassed for clearness, selectivity, long distance and volume"—"Tone is wonderfully clear and powerful"—"Distant programs come in loud and clear on speaker"—"Friends say it's the best and clearest they've heard"—"Beats 'em all for distance and clear tone"—"Amazingly selective-easy to tune and log"

Now only $59.50 Retail

Our Amazing Special Offer will interest you—send for it!



Built like—looks like—performs like a $200 set!

DEMAND IS ENORMOUS!—More User-Agents Needed!—Get Our Wholesale Prices Quick!

MIRACO RADIO GETS 'EM COAST TO COAST

Notice!

Tremendous demand for this big, beautiful, powerful, 1926 model Miraco Ultra 5—as a result of users everywhere so highly recommending it to their friends—makes possible the hosts of costly new features and latest improvements such as you expect to find only on sets at much **higher prices.**

COAST TO COAST RECEPTION VERIFIED BY USERS

Reports from Ultra-5 users everywhere leave little for us to add. These are only a few of the thousands in our files and which we receive daily:

MANY SAY IT'S BEST THEY'VE HEARD

"Ultra 5" more than meets my expectations of a good radio set. Many think it is the best that they have heard. For volume, selectivity, clearness and long distance it is unsurpassed in my estimation . . . . . Auto Supply, Allentown, Penna.

PRAISES THE FINE TONE AND VOLUME

The Ultra-5 has a fine tone and good volume; last night had 24 different stations from 8 to 10—all on loud speaker, O. T. . . . . Malone, New York.

THE TONE IS "WONDERFULLY CLEAR AND POWERFUL"

Am more than pleased with my 5 tube Miraco. Tone wonderfully clear and powerful. D. C. . . . . Detroit, Michigan.

MORE PRAISE FOR MIRACO TONE QUALITY

The Ultra-5 received from you is the best I ever heard. It is just as clear as a crystal. Raymond W, ... Massback, Ill.

ONE OF THE CLEAREST EVER HEARD

All who have heard my Ultra-5 set pronounce it one of the clearest they have heard, and I must say that the MIRACO is in every way as represented by you. George . . . . . Colville, Washington.

MONTANA HEARS BOTH COASTS

Ultra-5 set is O K. Have got them, New York to Los Angeles, Winnipeg to Dallas, Texas. W. H. . . . . Polson, Montana.

OHIO GETS 'EM COAST TO COAST

We are enjoying the Ultra-5 Radio. It is all you recommended. We get stations on the east coast, south and west coast, Walter . . . . . Van Buren, Ohio.

CALIFORNIA THE FIRST NIGHT

Headphones are not necessary with the Ultra-5 I had KFI, California, the first night with same volume as Pittsburgh. Fred G. . . . . Liverpool, Ohio.

COAST TO COAST FROM OKLAHOMA

With Miraco five tube set am getting stations on the Pacific and Atlantic coasts. Yerker E, ... Pauls Valley, Okla.

"COAST TO COAST" A REALITY

The two Miraco-5's have been working fine, in fact far beyond our expectations. Your statement of "coast to coast" reception proved absolutely a reality. T. D. . . . . Houston, Texas.

MICHIGAN GETS COAST TO COAST

I am overly pleased with the Miraco Ultra-5 Can get stations from coast to coast and from Texas to Canada. Geo. O' . . . . , Gordon, Michigan.

INDIANA HEARS BOTH COASTS

Miraco Ultra-5 is a first-class set in every respect. It can't possibly be beat for the price. The first night I received over twenty stations from both coasts. Adolph M. . . . . Indianapolis, Indiana,

MINNESOTA HEARS COAST TO COAST

Received Ultra-5 in fine condition. Have received programs from stations all over the United States and Canada. We find it is one of the best sets in this locality. We are well pleased with the wonderful results. Clarence . . . . . Nashwauk, Minn.

HEARS CALIFORNIA TO EUROPE

Enclosed is a partial list of the stations I received with the Miraco Ultra-5: KSD, WEBH, WBAV, WEAF, WLW, WCRD, WHB, WOR, WJAZ, WOC, WHAS, WWJ, CKAC, KFIX, WCK, WHAZ, KFAB, WHAA, WASL, WCAP, WTAS, WQJ, KFKX, WAAW, WTAM, WOAI, WSOE, WCCO, KDKA, WDAF, WMC, CNRO, WLS, WPJ, WBZ, WNH, KFNF, KFI, WEFI, WWL, WFAA, WAF, WGY, CKY, WRR, WCAE, WEAO, WRC, FFDM, WJJD, WGR, WABN, WCAL, WLB, WHN, WMAQ, WJZ, WLS, WOAW, WOO, WOS, CFAC, Sheffield (Eng.), Paris (France). Carl H. . . . . Waukesha, Wis.

MONTANA HEARS CALIFORNIA TO IRELAND

I am more than pleased with the Ultra-5 Receiver. I have 90 stations on my record in 20 days' time, including KDKA, WCAL, KFLE, WFC, WCC, WIAM, WEAF, WEM, WGM, WCAL, WLW, CAM, CFCF, WJJ, WAE, KAKF, KOOW, WCCO, WOC, WCAZ, WHO, WCCA, WOAW, CFAC, WOAI, WOS, WCKP, KFPU, KEB, KPO, KFAA, WMCR, CKY, WCCF, WMAW, WBAP, WGN, KJR, WBJ, WOS, WMC, WJJ, WGAN, KKU, WGW, WLW, WOOI, WHB, WFAI, WJAZ, KGB, WCAF, KSAC, WTAP, KSKI, KFKA. On February 16th at 12:15 o'clock I received Ireland, the distance being several thousand miles. Richard . . . . . Comertown, Mont,

WEST VIRGINIA HEARS AUSTRALIA

Get 2-XB Wellington, Australia, plain last night at 12:45 A.M. over the Ultra-5 Miraco you sold me. I am delighted and would not trade for any instrument in town. Geo. . . . . Glen Ferris, West Va.

ALL WE CLAIM . . . AND MORE.

Miraco Ultra "5" Set installed yesterday evening—had wonderful results last night. Think Ultra "5" is all you claim and more. V. A. . . . . . Hampshire, Tennessee.

LOTS OF VOLUME—20 STATIONS FIRST NIGHT

Will drop you a few lines to let you know that I received my Miraco Ultra-5 and that it works fine. Had 20 stations the first night—it has lots of volume. Fred . . . . , Versailles, Ill.

The reports we print are from UNSOLICITED letters sent us by pleased users.

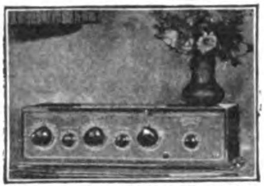
Send coupon for Amazing Special Offer!

The Powerful New MIRACO Ultra 5

Guaranteed by One of the Oldest Radio Builders

Tested and Approved by Radio's Highest Authorities

[ULTRA SELECTIVE FIVE TUBE SET IN MAHOGANY CABINET]



The improved new Miraco Ultra-5 is a beauty! Handsomely gold-etched genuine Formica panel and large bakelite knobs with "arrow point" indicators (for sharp tuning) add to the stylish appearance. A big set—27 inches long!

You can either *save* or *make* a lot of money on sets and supplies by sending coupon today for our *Amazing Special Offer!* It will astonish you. Big profits easy—accepting orders for Miraco Sets. Only necessary to order one set to demonstrate in your home. No agreements to sign—no salesmanship required. The performance of Miraco Sets does the selling. Greatest demand in the six years we have been building sets—we need more user-agents to supply it

This latest improved 1926 model Miraco Ultra 5—completely built, thoroughly tested and factory guaranteed by the Midwest Radio Corporation, one of America's oldest, reliable and most successful makers of quality sets—is an astonishing bargain in the opinion of radio experts. Selectivity, long distance reception, clarity of tone, power and volume have been amazingly increased—"B" battery consumption is minimized—oscillations are easily controlled on all wavelengths, through use of latest radio inventions. Among these are: "Duoformers" (ultra low-loss inductance coils); the "Counter-Balancer" (patented); flexible wiring which prevents broken or noisy connections; an adjustment for different length aerials; use of only two rheostats; a cutout switch; concealed wiring under genuine Formica baseboard and other features of costliest sets.

Literature describes them fully. Send for it—and Special Offer that will surprise and interest you.

Other Miraco Long Distance Sets $13.75 up retail

Wonderfully improved new models in one-tube and three-tube Miraco Long Distance Sets also ready at lower prices! New Miraco R-3 at only $27.35 (retail) operates loud speaker on distant stations. New one-tube Model R is also a record-breaker for distance at $13.75. All Miraco sets work on storage or dry batteries, are easily connected and operated. Unmatched values! Let testimony of users convince you. Write for literature and Special Offer—use coupon.

Get Special Offer!

AGENTS! DEALERS!

Write for the new Miraco proposition. Nation-wide use and popularity of Miraco sets, coupled with their amazingly low prices make them wanted everywhere.

All the Proof you want is waiting for You!

Reports from hosts of users in every state prove Miraco sets—at rock-bottom factory prices—outperform sets costing up to three times as much. Send for latest literature, SPECIAL OFFER and plenty of additional testimony leaving no doubt that "Miraco Radio Gets 'em Coast to Coast."

MIRACO RADIO GETS 'EM COAST TO COAST

MIDWEST RADIO CORPORATION
Pioneer Builders of Sets
479-M East Eighth Street
Cincinnati, Ohio

Send free literature, AMAZING SPECIAL OFFER and all particulars regarding your big money-saving proposition on Guaranteed Miraco Sets and all radio supplies.

☐ Agent ☐ User ☐ Dealer.

NAME ....

ADDRESS ....

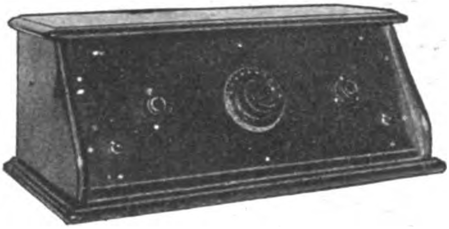
Specified Parts

Put up in Kit form or sold separately,

Mr. Laurence Cockaday's

L. C. 26

Broadcast Receiver



Improved four circuit tuner, single dial control, one stage of radio frequency amplification, cannot oscillate or radiate.

BLUE PRINTS FURNISHED

Parts Used by Mr. Cockaday in Building his Laboratory Set

		List Price
1	General Radio variometer, type 269, equipped with rheostat knob	$5.30
1	General Radio rheostat, type 214-a, 7 ohms, equipped with rheostat knob	2.25
1	Precision Octaform coil set	5.50
1	Amsco special double unit condenser No. 1814, each section .0003 mfd	6.25
1	Micamold fixed condenser, .00015 mfd	.35
1	Micamold fixed condenser, .00025 mfd	.35
2	Daven resisto-couplers (new type which incorporates .1 mfd. condenser in base)	3.00
1	Amertran DeLuxe transformer, first stage	10.00
	Bradleyleak ¼ to 10 meg	1.85
3	Bradleyunits, ¼ megohm	2.25
1	Bradleyunit, ½ megohm	.75
3	Amperites No. 1a	3.30
1	Amperite No. 112	1.10
5	Benjamin standard "Cle-ra-tone" sockets	5.00
1	Carter single circuit jack, No. 101	.70
2	Carter Jack switches, No. 2	2.00
8	Eby binding posts	1.20
1	Fynur vernier control knob and dial	3.50
4	Small brass brackets 1 Antenna connection block 1 x 2 inches 1 Battery connection block, 1 x 9 inches 2 large brass brackets	.15

Complete Parts (including 1 Bakelite drilled and engraved Panel 8 x 22") **Only $59.10**

GOING BIG

Specified Parts For

McLAUGHLIN

Single Dial Control

SUPERHETERODYNE

The hit of the Radio Exposition at the Grand Central Palace in New York

Reprint and full instructions how to build it, only 10c

FREE

New 1926 reference book (over 100 pages) containing illustrations, description and prices of every standard well known part, sent free on request.

HEINS & BOLET
44 PARK PLACE, NEW YORK

FREE PARTS

for

The New LC-26

Broadcast Receiver

IF you want to build your own set, here is your opportunity to secure FREE all the parts you need for this new LC-26 Broadcast Receiver. Call on all your radio friends and on anyone who has a set and tell them of the many special features of POPULAR RADIO.

These liberal offers will make it possible for you to secure an order from every one you call upon. For each subscription with remittance you send us you will receive credits as per the following scale:

POPULAR RADIO

4	Months	for	$1.00	counts	16	credits
6	"	"	1.50	"	25	"
8	"	"	2.00	"	33	"
12	"	"	3.00	"	50	"
24	"	"	5.00	"	75	"

Send us the full amount collected with names and addresses of subscribers and tell us the parts your credits entitle you to and we will send them to you. If the subscriptions you secure do not give you enough credits for the parts you want we will allow you to purchase credits at the rate of 3 cents each. *Example:* With (5) five 1-year subscriptions (250 credits) and 30 cents additional in cash you may have a General Radio variometer, No. 269 and a set of 8 Eby binding posts for which you need 260 credits.

If the parts you want are not listed on this page, we are prepared to supply them. Let us know what you want and we will tell you how many credits you will need.

On page 102 are described POPULAR RADIO's Simplified Blueprints. You can have any set of prints you want for only 44 credits. You may also secure a copy of "How to Build Your Radio Receiver" described on page 104 for 60 credits.

CREDITS Needed for Parts Required for The New LC-26 Broadcast Receiver

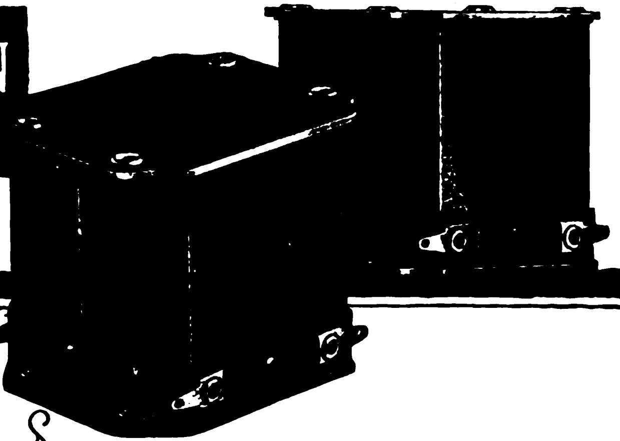
(Described and illustrated in this issue of POPULAR RADIO)

Quantity	Item	Credits
1—	General Radio variometer, type 269, equipped with rheostat knob	212
1—	General Radio rheostat, type 214-a, 7 ohms, equipped with rheostat knob	90
1—	Precision Octaform coil set	220
1—	Amsco special double unit condenser No. 1814, each section .0003 mfd.	250
1—	Micamold fixed condenser, .00015 mfd.	14
1—	Micamold fixed condenser, .00025 mfd.	14
2—	Daven resisto-couplers (new type which incorporates .1 mfd. condenser concealed in base) @ 60	120
1—	Amertran DeLuxe transformer, first stage	400
	Bradleyleak ¼ to 10 megohm	74
3—	Bradleyunits, ¼ megohm @ 30	90
1—	Bradleyunit, ½ megohm	30
3—	Amperites No. 1a @ .44	132
1—	Amperite No. 112	44
5—	Benjamin Standard "Cle-ra-tone" sockets @ .40	200
1—	Carter single-circuit jack, No. 101	28
2—	Carter Jack switches, No. 2 @ 40	80
8—	Eby binding posts	48
1—	Fynur vernier control knob and dial	140
1—	Universal decorated panel, 8 x 22 inches	300
1—	Genuine Walnut or Mahogany Cabinet and hardwood base	680
4— 1— 1— 2—	Small brass brackets Antenna connection block, 1 x 2 inches Battery connection block, 1 x 9 inches Large brass brackets } Complete	70
	Total	3.236

Write for List of Free Parts for Other Popular Radio Receivers

POPULAR RADIO
Department 121
627 West 43d St. NEW YORK CITY

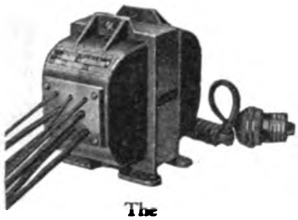
AMERTRAN
DE LUXE



AMERTRAN

Types AF-7 and AF-6

AmerTran audio transformers Types AF-7 and AF-6 have been considered for years among the leaders in audio amplification. These popular and efficient models may now be purchased at a considerable saving in cost. *Types AF-7 (ratio 3½:1)—AF-6 (ratio 5:1)* $5.00 each



The AMERTRAN Power Transformer

Type PF-45, 65 Va—60 cycles 110 volts primary, 450—8/4-8/4 secondary

Type PF-45 is intended for use on the standard 110 volt, 60 cycle house lighting circuit. It has three separate well-insulated secondary windings. These are enclosed in a strong metal case provided with mounting feet. The secondary leads are standard code flexible wires left long enough to reach the terminals in the average set without splicing. This transformer is well suited for supplying AC power for filter circuits, and is designed with the usual margin of safety $15.00 each

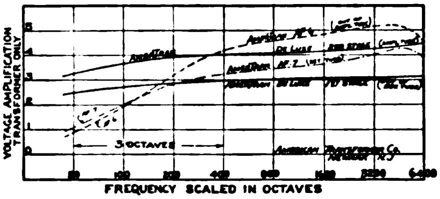
The New AMERCHOKE

Type 854

Type 854 is a scientifically designed impedance or choke coil of general utility, designed primarily for use in filter circuits. As an output impedance for by-passing direct current from the loudspeaker it is just as efficient and more economical than an output transformer. When used with a 1 mfd. (or greater) fixed condenser, the tone quality equals that of the best output transformer. DC saturation is prevented by two adjustable butt joints in the core. $6.00 each

A New Standard of Excellence in Audio Amplification

THIS new audio transformer has been developed for those who are satisfied only with the utmost in quality. It possesses an unusually straight line frequency characteristic extending the range below the lowest note now being broadcast, and actually shows a gain of about three octaves below that previously obtained.



The AmerTran De Luxe is a transformer of moderate size and weight, enclosed in a strong metal case with mounting holes at both top and bottom so that it may be inverted, affording simplified connections. While the AmerTran De Luxe will improve any set, appreciation of its uniform amplifying qualities can best be realized when operated in conjunction with straight line frequency loudspeakers, such as the best cone and disc types, and with a tube in the last stage capable of handling the output.

The AmerTran De Luxe is made in two types, one for the first stage and one for the second stage, and plainly marked as such. The chief difference between these two types is that the first stage transformer has approximately 50% greater primary inductance than the second stage transformer, thus more nearly corresponding to the operating impedances of the tubes out of which they work. For this reason it is advisable to purchase and operate these transformers by the pair!

PRICE, EITHER TYPE, $10.00

Write for descriptive booklet on AMERTRAN Radio Products

American Transformer Company
178 Emmet Street, Newark, N. J.
"Transformer builders for over twenty-four years"

SOLD ONLY AT
AUTHORIZED AMERTRAN DEALERS

WESTON
Radio Instruments
Specified by McLaughlin

Do YOU *use* a WESTON ?

Weston Model 489 Table Voltmeter

ANOTHER Weston quality radio product. This Double Range Voltmeter is perhaps the most versatile testing unit ever devised for radio use.

Supplied with pin jacks and flexible cables it is adaptable to testing on any make or type of receiving set.

Resistance 62 ohms per volt. Practically no appreciable current is used while testing.

Increase the useful life of tubes and batteries and make radio set operation a pleasure by using Model 489 Table Voltmeter.

For full details write for the new free booklet entitled "Weston Radio Instruments.

WESTON ELECTRICAL INSTRUMENT CORPORATION
115 Weston Avenue, Newark, N. J.

STANDARD THE WORLD OVER
WESTON
Pioneers since 1888

The Red Stripe
A Radio Guide Line

For your protection, throughout the center of every Dilecto radio panel is a Red Stripe. You can see it along the edge of every panel.

If you buy or build a set Look for the Red Stripe—and you'll be sure of the finest, strongest radio panel that can be made. Dilecto is a Phenolic condensation material.

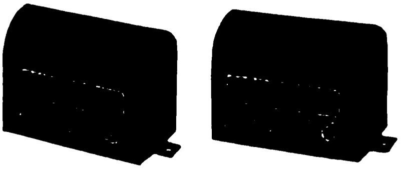
THE CONTINENTAL FIBRE COMPANY
Factory: Newark, Delaware

Service on Dilecto, Conite, Contex and Vulcanized Fibre from:

New York, 250 Park Ave.
Chicago, Wrigley Bldg.
San Francisco, 75 Fremont St.
Los Angeles, 307 S. Hill St.
Seattle, 1041 Sixth Ave., South
Pittsburgh, Farmers Bank Bldg.

Dilecto

"Take No Chances—Use Como"
COMO DUPLEX
The World's Standard Push Pull Transformer



PRICE $11.00 per pair

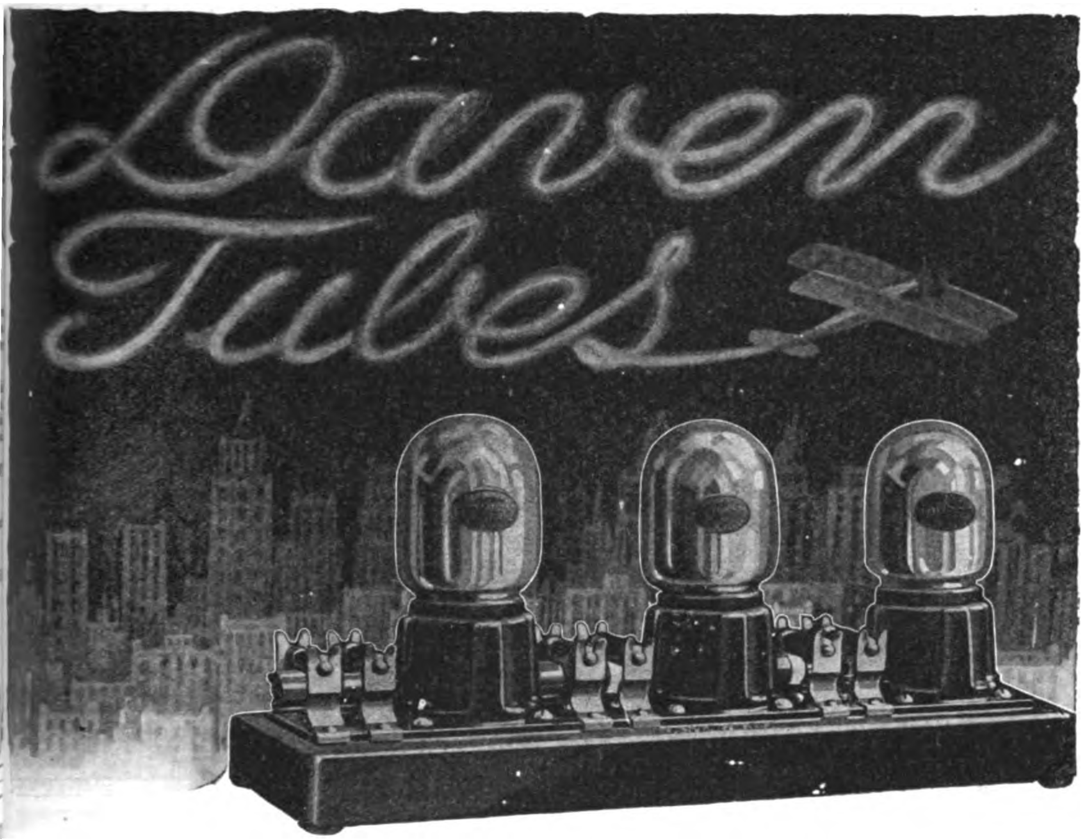
For maximum volume without distortion

What Prominent Writers on Radio Subjects say About Como.

Lewis B. Hagerman, Technical Editor, *Chicago Post:* "Actual Tests show this transformer to be far superior to any others of similar makes."
R. J. Robbins, *New York Sun:* "After consideration of several well-known makes of push pull transformers which are available 'COMO DUPLEX' was selected as most satisfactory."
C. White, *Radio World:* "'COMO DUPLEX' is infinitely superior — most other push pull transformers seem to be ordinary transformers with a center tap brought out as a makeshift."
E. P. Gordon, *Open Road:* "A system of audio-amplification which is becoming increasingly popular. its use . . . . will give surprising results in both quality and volume, and is thoroughly recommended by this department."

NEED WE SAY MORE?

COMO APPARATUS COMPANY
Manchester, New Hampshire
For Sale at Leading Dealers



Resistor Manual
The Handbook of Resistance Coupled Amplification at best radio dealers 25c. Direct by mail, postpaid 30c.

CLIP THIS COUPON

D-12-25

DAVEN RADIO CORPORATION
158-160 Summit Street
Newark, New Jersey

Please send me the following on Resistance Coupled Amplification:

Check one.

☐ Resistor Manual. 30c is enclosed.
☐ Complete catalogue (free)

Name..........................

Address.......................

For dealers: Send your letterhead or card, or this coupon and we will have our nearest distributor communicate with you.

Resistance Coupled Amplification For All

THE Daven Super-Amplifier is for set owners who want more volume or for set builders or manufacturers who want resistance coupled amplification without the labor of assembly.

All the plate resistors, grid leaks and fixed condensers of the proper value, as well as all necessary binding posts, are supplied. There is nothing to do but connect with the tuner and the batteries.

Thousands have changed over their amplifiers to the resistance coupled system and testify to the wonderful improvement in richness and sweetness of tone and hearty, generous volume. The Daven Super-Amplifier makes even the best set a little better.

A ONE-PURPOSE TUBE

The new Daven Tube MU-20, 6 volt, ¼ ampere, increases the amplification of The Daven Super fifty percent, without distortion. The tone remains sweet and true. Daven Power Tube Type MU-6 is recommended for the last or output stage in any set.

Any Daven dealer will show you how to hook up the Daven Super-Amplifier.

DAVEN PRODUCTS ARE SOLD ONLY BY GOOD DEALERS

"The Line of Merit"

DAVEN RADIO CORPORATION

Resistor Specialists

Newark Reg. U. S. Pat. Off. New Jersey

THE BIG LITTLE THINGS OF RADIO

OTHER STERLING HOME ACCESSORIES

- ¶ *Tube Reactivators*
- ¶ *Battery Chargers*
- ¶ *Pocket Meters*
- ¶ *Panel Meters*
- ¶ *Rheostats*
- ¶ *Transformers*
- ¶ *Microcondensers*

Now You Can Test peanut tubes right in your set!

Is there one bad tube in your set—a tube that is poor or only fair in amplification value? Find it with the Sterling Tube Tester. The new number 399 Tester is for small tubes, No. 401 is for large tubes.

This simple tube tester operates right in the radio set—anyone can use it, and by glancing at the chart that comes with it tell instantly whether tubes are good, fair or poor. The tester is also a trouble chaser for wiring leaks, weak sockets and transformer troubles.

THE STERLING MANUFACTURING CO., CLEVELAND OHIO

Sterling TUBE TESTER

Price $10.00

For small tubes No. 399—for large tubes No. 401

BROADCAST LISTENERS

THE POPULAR RADIO ATLAS AND LOG will give you a list of all the NEW Broadcasting Stations with wavelengths and other necessary information

To receive the full benefit of your set you should have a complete log of the principal broadcasting stations and a convenient place to note your dial readings when you "pick-up" any of them.

A Complete Atlas and Station Log

The "Popular Radio International Radio Atlas and Log" will supply you with full information regarding broadcasting stations of the United States and Canada.

This most useful and practical Atlas, consists of 16 pages, size 12" x 15" printed on good paper, from clear type in two colors and contains a complete series of double page maps, including—The World—The United States—Canada—North and South America, showing location of principal broadcasting, leading commercial and governmental radio stations. In addition these maps show time zones and Radio Districts with Headquarters and also the district zoning of the American Radio Relay League.

There is also included in this Atlas a list of all United States and Canadian stations, alphabetically arranged, giving signals, wavelengths, kilocycles, ownership and other important data, with space for logging three dial readings.

The Leading Radio Monthly

In Popular Radio, with which is combined *The Wireless Age*, each month you will find the very latest news of the radio field with many entertaining, interesting and instructive articles of interest to Radio Fans. With Popular Radio and the "Popular Radio International Radio Atlas and Log" you will have available the two most useful adjuncts to full enjoyment of your radio receiver.

POPULAR RADIO
627 West 43d Street New York City

SPECIAL FREE OFFER

You may have a copy of the "Popular Radio International Radio Atlas and Log" free, with Popular Radio for (8) eight months

For Only $2.00

Pin $2.00 in bills to the coupon below.

If you are a subscriber to either Popular Radio or *The Wireless Age*, your subscription will be extended eight months.

Date........................

Popular Radio, Dept. 122A,
627 West 43d St., New York City.

Enclosed is my remittance of $2.00 for which you are to enter my subscription (extend my subscription) for (8) eight months for Popular Radio and send FREE a copy of the "Popular Radio International Radio Atlas and Log."

Name..

Address..

City................................State..............

Mohawk

Manufactured by Mohawk Corporation
of Illinois. Independently Organized in 1924

Radios–Kits–Parts

ENJOY three-dial results with a single dial Mohawk Five-Tube Receiver. The secret is its three-in-line *balanced* condenser. This condenser is exclusive to Mohawk.

Before buying or building a new radio, be sure that you see, hear and tune the Mohawk. Reliable dealers sell the famous Mohawk—"five tubes, just one dial to tune." Or, if you prefer to assemble your own, they can supply you with a Mohawk Kit containing genuine Mohawk parts.

If you now have a set, and wish to rebuild, you can easily convert it to an efficient one-dial radio by installing the Mohawk Condenser. Radio parts bearing the name "Mohawk" are unassailable in quality and performance. Sold by leading dealers.

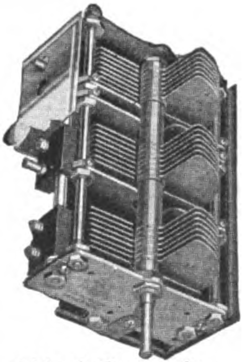
The Mohawk was selected from 47 radios as standard equipment on the Pan-American, crack train of the L & N Railroad. A test will tell you why.

Manufacturers
MOHAWK CORPORATION OF ILLINOIS
Independently organized in 1924
CHICAGO, ILL.
Sales Department
THE ZINKE COMPANY
1323 So. Michigan Ave.
CHICAGO, ILL.

Mohawk No. KU51 Kit, including all parts, with cabinet, ready for quick assembly. Price, $75.

Mohawk No. 143 Kit. Includes Mohawk Three-in-line balanced condenser; Mohawk Selectune Dial; three standard Mohawk radio-frequency transformers. With this kit, you can convert any three-dial, five-tube tuned radio-frequency radio into a one-dial set. $23.50.

Mohawk Radio, "5 tubes, just one dial to tune." [Accessories extra.] $100.



Mohawk Three-in-line balanced condenser—"the heart of the Mohawk Radio." $15.

Accuracy guaranteed within 10 per cent of marked capacity.

Corrects salt-air troubles

RADIO sets located anywhere near the sea are particularly subject to condenser trouble. Salt air creeps in and causes corrosion. Then comes distortion—if your set will work at all. Don't assume that your condensers are right! Put in Sangamo Mica Condensers—solidly molded in bakelite—and no service can ever change their accuracy.

Sangamo Mica Condensers

Every Sangamo Mica Condenser is separately tested at the factory. If it does not come within very fine limits, it is rejected. You can solder it, boil it, freeze it, or subject it to heavy electrical surges—but the capacity stays exactly the same. The bakelite jacket is impervious, and nothing gets through to the delicate parts inside.

All wide-awake dealers carry Sangamo Mica Condensers or know where to get them for you quickly. Put them in when you build your set and you will never have fixed condenser trouble.

SANGAMO
Accurate
Radio Parts

ALSO AVAILABLE
SANGAMO
By-pass Condensers
1 Mfd.—$1.25
½ Mfd.— .90

Sangamo Electric Company

1421-3 *Springfield, Illinois*

RADIO DIVISION, 50 *Church Street, New York*

SALES OFFICES—PRINCIPAL CITIES
For Canada — Sangamo Electric Co. of Canada, Ltd., Toronto.
For Europe—British Sangamo Co., Ponders End, Middlesex, Eng.
For Far East—Ashida Engineering Co., Osaka, Japan

"a new 5-Tube Set with all the power and none of the grief of the Supers"—so wrote Henry M. Neely, Editor of Radio in the Home, Philadelphia.

Get This Book

Write today for this big fascinating 32-page booklet which tells how *you* can build the truly amazing new QUADRAFORMER receiver. Based on a new radio principle, five tubes give remarkable results.

Enclose 10c and you'll have it by return mail

Gearhart-Schlueter Radio Corp'n
713 Voorman Avenue, Fresno, California

GET YOUR SET OF SIMPLIFIED BLUE PRINTS FREE

You know how helpful, interesting and practical POPULAR RADIO is. You fully appreciate that at $3.00 a year it is a real bargain. Consequently you should find it easy to convince one, two or more of your friends, who are not now subscribers, of the unusual value when any one of these seven sets of Simplified Blueprints (described on page 102) is offered free with their twelve months' subscription for POPULAR RADIO at the regular price of $3.00.

In addition to the Blueprints given to your friends we will allow you one set free for each *new* subscription you send us with a $3.00 remittance. Five *new* subscriptions and remittance of $15.00 would entitle you to five sets free.

Only one set of Blueprints free with a renewal subscription whether your own or a friend's.

POPULAR RADIO, INC., Dept. 123
627 West 43d Street, New York City

Enclosed is my remittance of $ covering annual subscriptions for POPULAR RADIO (names on sheet attached). Send me set (s) checked below.

☐ Set No. 4
☐ Set No. 6
☐ Set No. 7
☐ Set No. 9
☐ Set No. 11
☐ Set No. 12
☐ Set No. 13
☐ Set No. 14

(See page 102 for description of Sets)

Name..

Address..

....

Foreign postage 50c. extra. No extra for Canada.

Standard Bearers of an Ideal

BACK of every Ferguson Receiver—since the pioneer days of broadcasting—stands the Ferguson Ideal: "Fewer but Better" Receivers. Each is a precision-built Standard Bearer of this Ideal.

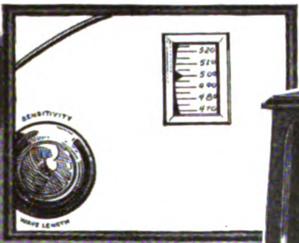
The owner of a Ferguson feels that well-founded pride of ownership which comes only with the possession of a true musical instrument of graceful dignity and charm, that will be a welcome addition to any home for years to come.

You can always count on a Ferguson. Hear one in a comparative test with others and you'll learn why it has been acclaimed "The Gold Standard of Radio Receivers."

There could be no more fitting testimony of the true worth of Ferguson Receivers than the well-balanced growth of the Ferguson business; the ever-increasing number of Ferguson enthusiasts.

See and hear the Ferguson Model "Eight" at your Authorized Ferguson Dealer's.

J. B. FERGUSON, INC.
41 East 42nd Street · New York, N. Y.



Just choose your program, turn to its wavelength, and in comes your station!

One Tuning Control—Calibrated in Meters!

Ferguson

J.B. INCORPORATED

The Gold Standard of Radio Receivers

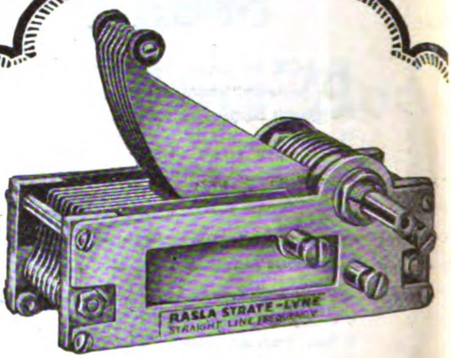
Separates Stations!

JOHN CLYDE DAVIDSON, Rasla chief engineer, personally endorsed this condenser—but only after assuring himself that it is the best straight line frequency condenser possible to produce. It *really* separates stations.

The RASLA STRATE-LYNE is built to standards usually adhered to only for laboratory precision instruments. The plates are *heavier* than on any other condenser, the spacing and alignment is more accurate. Split bushings are provided at *both* ends. The plates are acid dipped, the end plates nickelled and highly polished. Transparent bakelite insures *true* low loss.

RASLA STRATE-LYNE

Straight Line Frequency Condenser



The Rasla Fixed Detector is sensitive—and remains so. Best for reflex or any circuit. At your dealer's **$1.25.**

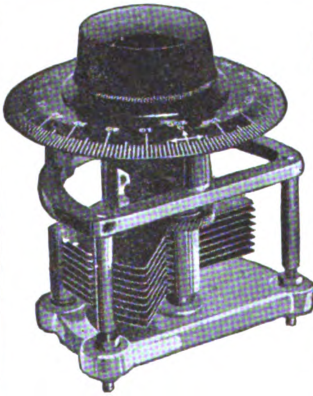
FREE—Write for the complete Rasla hook-up:

Davidson Radio Corp., 222 Fulton St., N.Y.

LIST PRICES

.00025	$4.60	.00035	$5.00
.0003	4.75	.0005	5.25

At your dealer's or direct if he can't supply you



QUAM

Condensers—with the Pyrex end plate are lowest loss and highest quality. Used as laboratory standard in all parts of the world. Outstanding features include:—

1¼" leakage paths on Pyrex end plate. 2 to 1 helical gears for sharp tuning. No back lash. Brass frame with brass plates soldered in place. Furnished straight-line wavelength and straight-line frequency. Quam condensers will improve *your* set. $6 and up. With 360 degree bakelite dial, add $1.

Quam audio transformers for better amplification—$5.

QUAM RADIO CORPORATION

1925 S. Western Ave., Chicago, Ill.

Establish Yourself in a Paying Business—No Capital Required

Right now, there is an opportunity in your locality to profitably devote your spare time or all your time to a pleasant, easy and profitable business—one that does not require any training or capital.

The publishers of POPULAR RADIO, *with which is combined The Wireless Age*, offer you an opportunity to become their local representative to take care of expiring subscriptions and new subscriptions for POPULAR RADIO and four other popular magazines that they publish.

SALARY AND COMMISSION

All material will be furnished you free of charge and you will be paid an attractive commission and salary.

Mail coupon for full particulars to

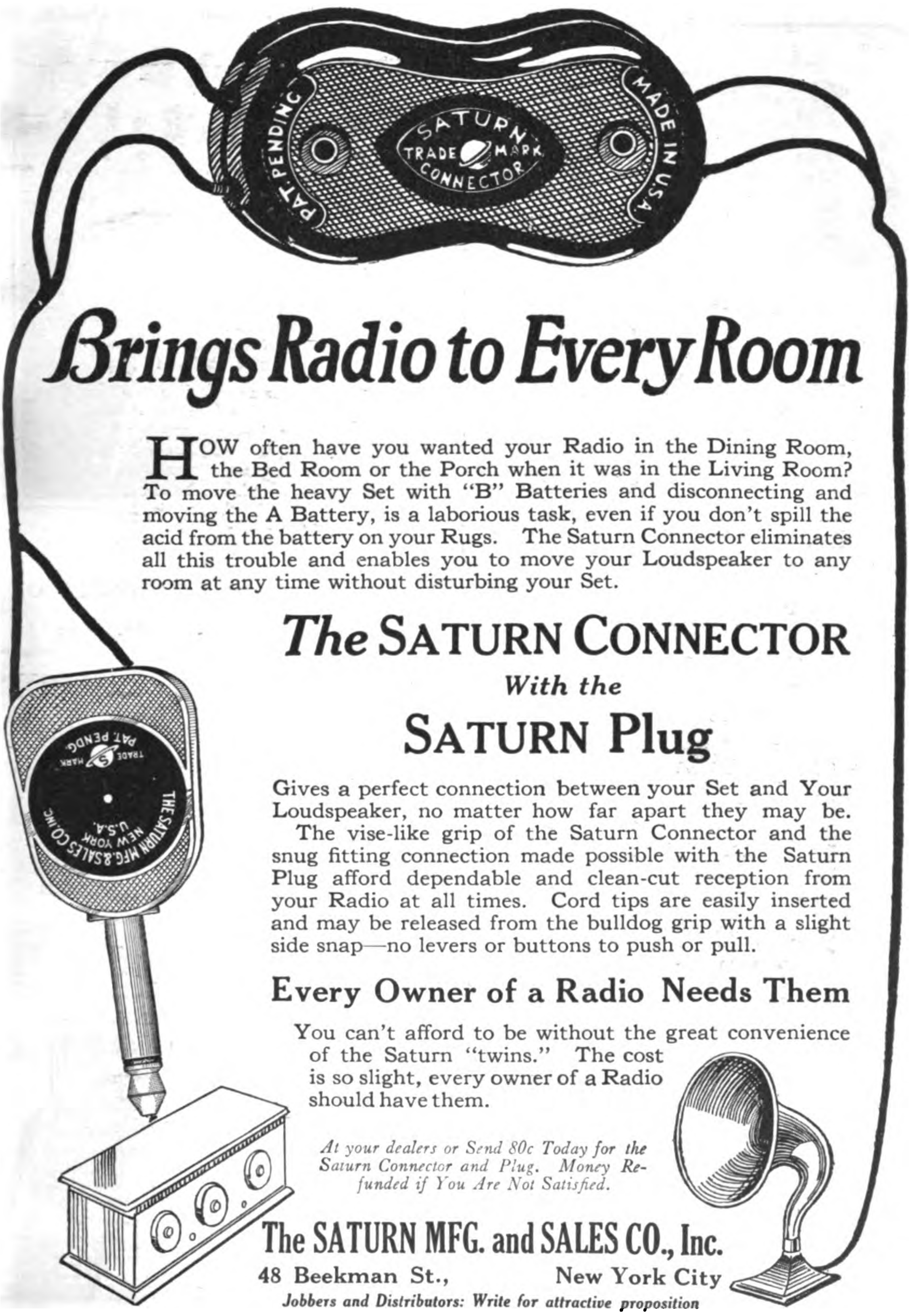
POPULAR RADIO
627 WEST 43rd ST. NEW YORK CITY

POPULAR RADIO, Dept. 126,
627 W. 43rd St., New York City

Send me full particulars regarding your salary and commission offer to local representatives.

Name..

Address..


SATURN TRADE MARK CONNECTOR
PAT. PENDING
MADE IN U.S.A.
THE SATURN MFG. & SALES CO. INC.
NEW YORK U.S.A.
TRADE MARK
PAT. PEND.

Brings Radio to Every Room

HOW often have you wanted your Radio in the Dining Room, the Bed Room or the Porch when it was in the Living Room? To move the heavy Set with "B" Batteries and disconnecting and moving the A Battery, is a laborious task, even if you don't spill the acid from the battery on your Rugs. The Saturn Connector eliminates all this trouble and enables you to move your Loudspeaker to any room at any time without disturbing your Set.

The SATURN CONNECTOR

With the

SATURN Plug

Gives a perfect connection between your Set and Your Loudspeaker, no matter how far apart they may be.

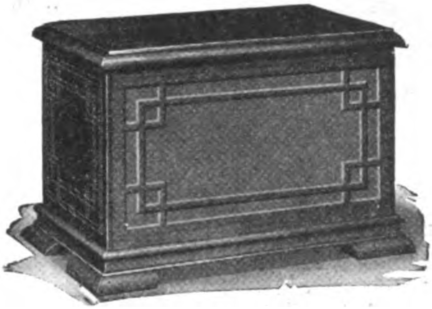
The vise-like grip of the Saturn Connector and the snug fitting connection made possible with the Saturn Plug afford dependable and clean-cut reception from your Radio at all times. Cord tips are easily inserted and may be released from the bulldog grip with a slight side snap—no levers or buttons to push or pull.

Every Owner of a Radio Needs Them

You can't afford to be without the great convenience of the Saturn "twins." The cost is so slight, every owner of a Radio should have them.

At your dealers or Send 80c Today for the Saturn Connector and Plug. Money Refunded if You Are Not Satisfied.

The SATURN MFG. and SALES CO., Inc.
48 Beekman St., New York City
Jobbers and Distributors: Write for attractive proposition



Trimm Chello Speaker selling at $30 represents the ultimate in reproducing performance and design. Beautiful American Walnut Cabinet is pleasing in appearance. The Trimm Unit, reproducing all the tones found in radio with perfect fidelity, may be adjusted to give desired volume.

Volconite Tone chamber eliminates the noises and overtones which ruin broadcast reception. There is nothing superior in reproducers to the Chello, regardless of price.

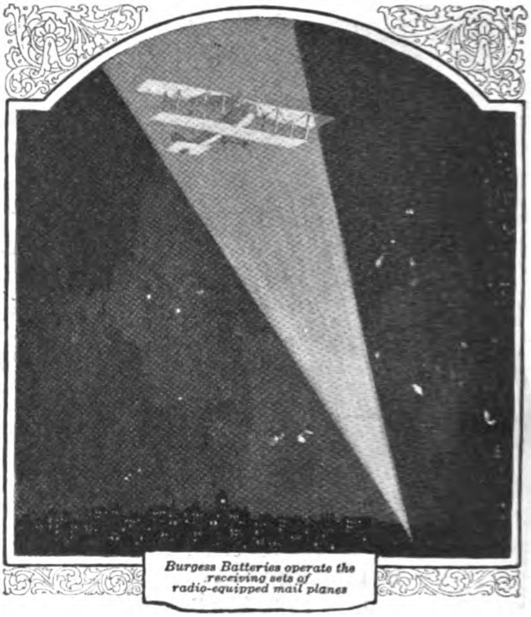
TRIMM
Superior Reproducers

HEADSETS	
Professional - -	$5.50
Dependable - - -	4.40
PHONODAPTERS	
Giant Unit - -	$10.00
Little Wonder -	4.50
SPEAKERS	
Home Speaker -	$10.00
Entertainer - -	17.50
Cabinette - - -	17.50
Concert - - -	25.00
Chello - - -	30.00

TRIMM
RADIO MANUFACTURING COMPANY
24 So. Clinton St.
CHICAGO
U.S.A.

MEMBER R.M.A.

ASK . . ANY . . RADIO . . ENGINEER



Burgess Batteries operate the receiving sets of radio-equipped mail planes

An every night adventure of Burgess Radio Batteries

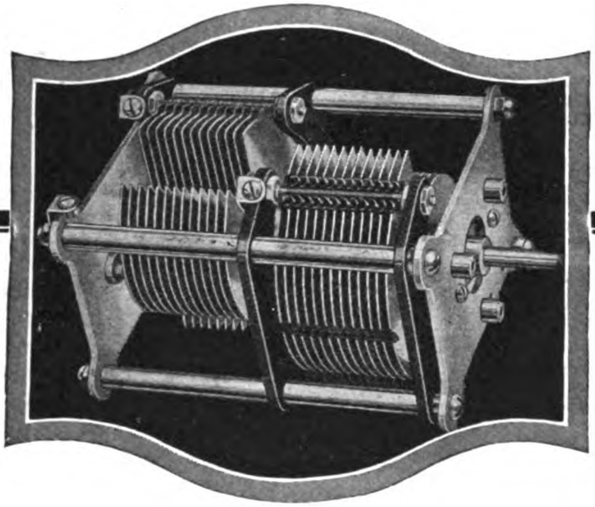
ONE of the reasons why you should always buy Burgess Radio Batteries is that the batteries used by air-mail pilots—battleships—explorers—and the majority of recognized radio engineers—are evolved in the Burgess Laboratories and manufactured in the Burgess factory.

These batteries are identical with the batteries sold by your dealer and thousands of other good dealers everywhere.

Burgess Battery Company
General Sales Office: Chicago
Canadian Factories and Offices: Niagara Falls and Winnipeg

BURGESS RADIO BATTERIES

The S. L. F. that doesn't "hog" panel space



The principle objection to many Straight Line Frequency condensers now on the market is that they "hog" too much panel space; thus making it necessary to re-arrange other instruments on the panel or rebuild the set entirely to allow enough room for the scythe-like sweep of the S. L. F. rotor.

The new General Radio type 374 S. L. F. condensers eliminate entirely all such difficulties. They occupy the same panel space as the well known types 247 and 334 condensers—and no more. In fact they may be used inter-changeably with those condensers since the mounting holes are the same.

By using smaller rotor plates of correct shape and double the number of plates General Radio condensers have a straightline frequency calibration curve without the mechanical disadvantages encountered in the average S. L. F. with fewer plates of larger area. The assembly of the type 374 condensers with respect to bearings, soldered-plates, and correct spacings are the same as the types 247 and 334. They are available in all standard capacities.

For further description and prices ask to see them at your local dealers or write for our latest Bulletin 923-P.

GENERAL RADIO COMPANY
30 State Street Cambridge, Mass.

GENERAL RADIO

"Behind the Panels of Better Built Sets"

LEADER PRODUCTS—

The most essential qualities of a loud speaker horn are clarity, volume, and faithful reproduction of tone. In LEADER loud speakers these qualities are carefully balanced to give a practical and satisfactory result.

The cast aluminum Goose Neck is a special feature which preserves the natural quality and clarity, preventing distortion from unnecessary vibration.

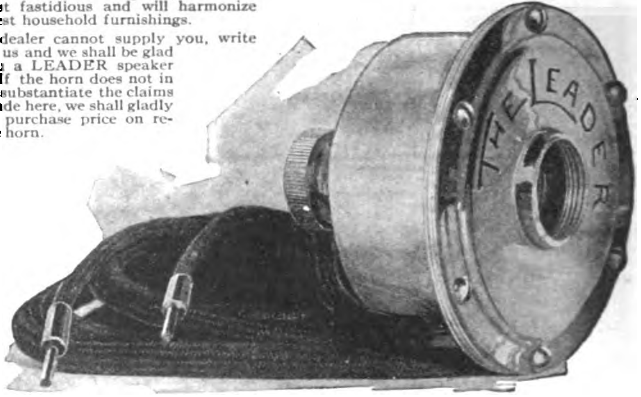
LEADER horns are graceful in appearance and beautifully finished in mahogany and wine gold. They will gratify the taste of the most fastidious and will harmonize with the best household furnishings.

If your dealer cannot supply you, write directly to us and we shall be glad to ship you a LEADER speaker at once. If the horn does not in every way substantiate the claims we have made here, we shall gladly return the purchase price on receipt of the horn.

The LEADER *loud speaker unit* is designed to fit any horn, console, or phonograph. It is the same unit which is used in LEADER speakers.

The laminated core and magnet used in its construction is, to a large extent, responsible for its faithful reproduction. A five-foot cord is attached.

It is provided with a simple adjusting knob for regulating volume and tone quality.



TWO SIZES

Leader Senior	**$18.00**
Leader Baby Goose Neck	**$14.00**

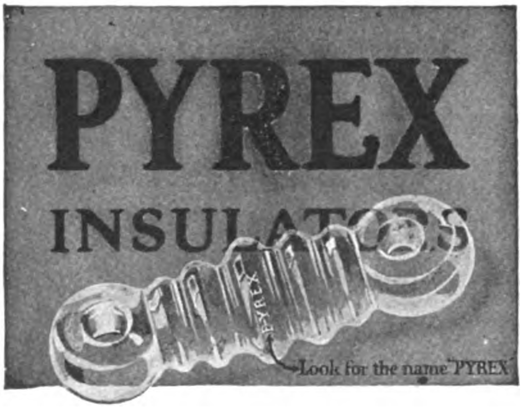
The LEADER, SR., is 22 inches high and the diameter of the bell is 13¾ inches. Greater in size, it produces more volume than the Baby Goose Neck.

The LEADER BABY GOOSE NECK is similar to the LEADER, SR., except that it is 18 inches high and the bell has a diameter of 12 inches.

Dealers, write for discounts to

List Price, UNIT $5.00

Victor Radio Corporation, **4321 No. Western Avenue, CHICAGO**



PYREX Insulators are used by the United States Government for the most exacting service. They must not be confused with ordinary glass insulators.

Make Your Set Weather Proof!

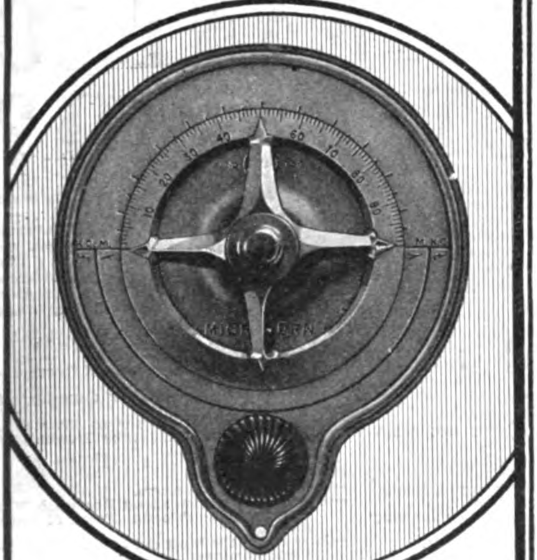
Because Pyrex Insulators are diamond hard and crystal smooth, they are not affected by rain or snow. Little drops of moisture cannot gather on them. They remain leak-proof in spite of the weather. They continue to conserve every available bit of energy.

Put in Pyrex Antenna Insulators and get more pleasure out of stormy nights. That's when you most want to use your set. They cost only 45c each at good dealers.

Industrial and Equipment Division

CORNING GLASS WORKS, Corning, New York

World's Largest Makers of Technical Glassware



PACENT MICROVERN— A SUPER TUNING DEVICE

PACENT *TRUE* STRAIGHT-LINE *FREQUENCY* CONDENSER

Pacent Electric Company, Inc.
91 Seventh Ave., New York City

Washington
Birmingham
Detroit
Chicago
Jacksonville
San Francisco
Buffalo
Boston
St. Louis
Minneapolis
Philadelphia
Pittsburgh

Canadian Licensed Manufacturers: White Radio Limited
Hamilton, Ont.

Pacent
RADIO ESSENTIALS

"DONT IMPROVISE — PACENTIZE"

Pacent
Engineering Achievements

DESIGNED and built by engineers in America's largest 100% radio laboratory and factory. You cannot buy better parts. They are backed by a name that is your guarantee of perfection both in workmanship and results.

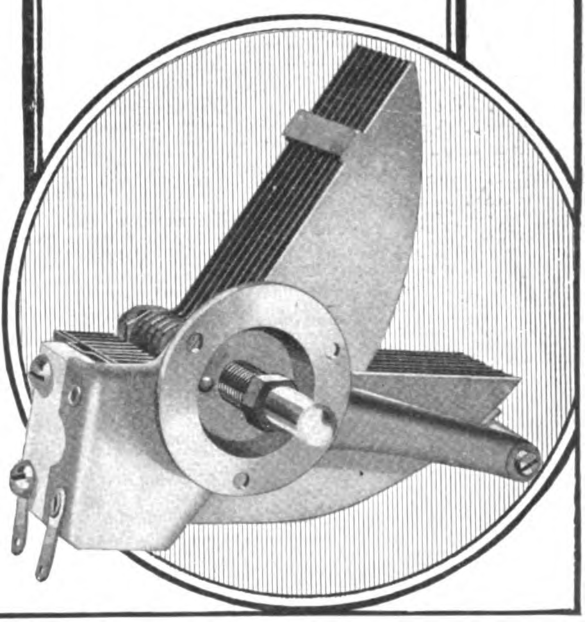
The Pacent Microvern solves your tuning problem. It *definitely holds* the minutest variations, and logs your stations by name, wavelength and frequency.

Cat. No. 150S. Silvered. Price $2.00
Cat. No. 150G. Gold Finish. Price $2.00

The Pacent *TRUE* S. L. F. Condenser—built from start to finish to chart a *true straight line*—results in an even spacing of stations on the dial according to frequency.

Cat.No. 250B. .00035 Mfd. Max. Price $3.50
Cat.No. 250C. .0005 Mfd. Max. Price $4.50

Get them from your dealer—or write



WHAT DO YOU WANT TO KNOW ABOUT RADIO?

POPULAR RADIO, *with which is combined The Wireless Age*, maintains for the benefit of its readers a Technical Service Bureau and Laboratory, under the personal supervision of Laurence M. Cockaday which will, without charge, answer by personal letter any question, problem or request for information submitted by a subscriber. This service is, however, also available to readers, other than subscribers, at the very nominal rate of 50 cents the inquiry.

In writing please confine your questions to one general subject, writing on one side of the paper only, and enclose a self-addressed and stamped envelope.

It is possible that your individual problem has been covered in an issue of POPULAR RADIO, and so as an aid to you we endeavor to keep a supply of back numbers in stock. The condensed index below gives a few of the subjects that have appeared recently, look this list over and if the information you want is covered, we will be pleased to supply back numbers at 35c. a copy.

July, 1923
—The ratio in size between your antenna and your coil.
—Useful facts about ear-phones.
—How to make a dry-cell tube Regenerative Set.
—How to keep up your storage battery.

August, 1923 (Out of stock)
A reprint of the Tuned Radio Frequency Receiver will be found in POPULAR RADIO'S HANDBOOK. See page 60.

September, 1923
—How to get a radio license.
—How weak signals are regenerated.
—How to make a battery charging rectifier.
—How to build the Haynes DX receiver.

October, 1923
—Practical hints for Coil Calculations.
—How to make a Two-stage Audio-frequency Amplifier.
—Ten good rules for Broadcast Listeners.
—How to make a simple Honeycomb Receiver.

November, 1923
—The 100 Best Hook-ups (Part 1).
—Receiving without Antennas.
—How to build the New Regenerative Super-heterodyne Receiver (Part 1).
—How to build a combination Short and Long-wave Receiver.

December, 1923
—How to Select your Radio Parts.
—The 100 Best Hook-Ups (Part 2).
—How to Read a Diagram (Part 1).
—How to build an efficient Crystal Receiver.
—How to Build the Super-heterodyne Receiver (Part 2).

January, 1924 (Out of Stock)
(A Reprint of Mr. Cockaday's article describing the DX Regenerative Receiver may be had for 25 cents.)

February, 1924
—How to add "Push and Pull" amplification to the 3 tube Cockaday 4-Circuit tuner.
—The original 4-Circuit Tuner as a Portable Set with Loop.
—The 100 Best Hook-ups (Part 4).
—How to build a 3-tube Reflex Receiver.

March, 1924
—Hoffman Transformer Measurement Chart.
—The 100 Best Hook-ups (Part 5).
—How to Build an Amateur Transmitter.
—A 3-tube Reflex Receiver (Part 2).

April, 1924
—How to Build a Simplified Neutrodyne. Receiver.
—The 100 Best Hook-ups (Part 6a)
—How NOT to Tune the Single Circuit Receiver.
—A Novel Substitute for "B" Batteries.

May, 1924
—A Compact Radio Kit for a Spring Hike.
—How to Get the Maximum Radio-frequency Amplification.
—100 Best Hook-ups (Part 6b).
—Where Interference Comes In.
—How to Make an Audio-frequency Amplifier that Does Not Distort.

June, 1924
—How to Install a Receiver on your Boat.
—The 100 Best Hook-ups (Part 7).
—How to Build a Regenerative Receiver for Use with an Indoor Antenna.
—How to Make a Two-Slide Tuner.

July, 1924
—How to Avoid Local Interference.
—How "Resistance" Affects Radio Circuits.
—An Ideal Set for Summer-time Reception.
—100 Best Hook-ups (Part 8).
—How to Do Your Soldering Correctly.
—How to Build the POPULAR RADIO Portable.

August, 1924
—How to build a single dry-cell tube, four circuit tuner.
—How to build a two tube reflex receiver.
—Helpful hints for the broadcast listener.

September, 1924
—How to build a single dry-cell tube reflex receiver.
—How to build a multi-wave tuner.
—How to improve broadcast reception.

October, 1924
—How to build the (Cockaday) Four Circuit Tuner with a Resistance-coupled Amplifier.
—How to Select a Ready-made Receiver.
—How to Build a Detector-amplifier.
—A Radio Set to Pack in Your Suitcase.
—Harnessing the Radio and the Movie.

November, 1924
—How to Locate Interference from Power Lines.
—Cockaday Article for Beginners.
—How to Build a Low-loss Tuner for Short-wave Reception.
—The New Type of Superheterodyne.

December, 1924
—How to Build a Non-radiating 7-tube Superheterodyne Receiver.
—Cockaday Article for Beginners.
—How to Get the Most Out of Your Ready-made Receiver.

January, 1925
—How to Build the Cockaday 8-tube Super-heterodyne Reflex Receiver.
—How to Improve Broadcast Reception.
—Cockaday Article for Beginners.

February, 1925
—How to Get on a Radio Program.
—A Loudspeaker for a Crystal Set.
—How to Build a 4-tube Reflex Receiver with the New Sodion Detector.
—Cockaday Article for Beginners.

March, 1925
—How to Build the Improved DX Regenerative Receiver.
—Factors that Govern the Capacity of Condensers.
—What "Induction" Means to Your Set.
—A Five Meter Vacuum-tube Transmitter and Receiver.

April, 1925
—Single Control Receivers.
—How to Improve Broadcast Reception, VI: Increasing the Selecting Power of Your Receiver.
—How to get the Most out of Your Ready-made Receiver.
—Quartz Crystal as a New Wavelength Standard.

May, 1925
—Factors That Affect Antenna Capacity.
—How to Wire Your Home to Have Radio in Every Room.
—Handy Tools for Radio Fans, The Hydrometer.
—How to Build the "Portable Town and Country Receiver."

June, 1925
—New Development in Vacuum Tubes.
—How to Build a Five-tube A-C Receiver.
—How to Draw Up Your Own Tuning Chart.
—Watt's Law in a Nutshell.
—"What Set Shall I Buy?"
First Installment.

July, 1925
—The Best 101 Hook-ups.
—"What Set Shall I Buy?"
Second Installment.
—Broadcast Stations in the United States.
—What's New in Radio Apparatus.

August, 1925
—"Motion Pictures" by Ether Waves.
—A New Type of Hornless Loudspeaker.
—How to Build a 5-Tube Radio-Frequency Set with Simplified Control.
—Trouble Shooting.
—Hints for Amateurs.

September, 1925
—How the Air Affects Radio.
—When You Turn Your Dials.
—Useful Charts for Amateurs.
—Call Letters That Have a Past.
—Broadcasts.

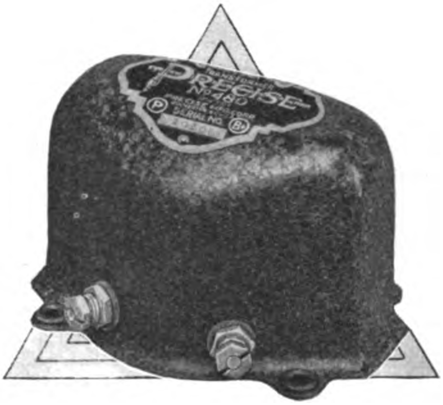
October, 1925
—How Earth Magnetism Affects Radio Waves.
—How to Improve Broadcast Reception.
—What Makes a Low-loss Coil?
—How to Build the New 8-Tube Superheterodyne with a Single Control.

November, 1925
—Radio's Newest Instrument—the Photo-electric Cell.
—How to Build the Raytheon Plate Supply Unit.
—New Methods of Calibrating Your Receiver.
—Practical Pointers About Transformers.
—Multi-layer Coils.

Popular Radio

627 West 43d Street **Dept. 128** **New York City**

Every Precise Instrument Is a Laboratory Product



**List Price
$7.50**

McLaughlin specifies Precise!

Volume *Without* Distortion

Most radio receivers have ample volume, but few have volume without distortion. Turn your rheostat on to its full power and notice how the range of tones dwindle and the crescendo rasps harshly on your ears. Be sure your drawing room radio entertainment gives pure tone quality.

The New Precise Supersize No. 480 Audio Transformer was designed to bring forth with magnificent volume a remarkable range of pure tones. With the Precise No. 480 you can dance and entertain with radio music that is ample in volume and harmonious in tone.

Mr. James L. McLaughlin, the noted superheterodyne authority specifies the Precise No. 480 for his new One Control Receiver.

**No. 285 The Original Type 285 Transformer Ratio 4½ to 1
Price $5.00**

PRECISE
MANUFACTURING CORPORATION.
LABORATORIES AND WORKS
ROCHESTER, NEW YORK

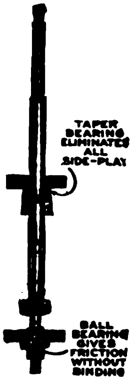
**COMET
Ratio 3½ to 1
Price $3.25**

Branch Offices:

126 Liberty St., New York City
205 W. Harrison St., Chicago, Ill.
821 Market St., San Francisco, Cal.
454 Builders Exchange, Minneapolis, Minn.
1127 Pine St., St. Louis, Mo.
701 A. O. U. W. Bldg., Little Rock, Ark.

Canadian Distributors:

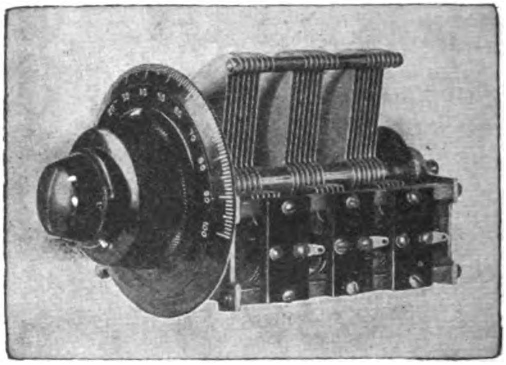
PERKINS ELECTRIC, Ltd., Toronto, Montreal, Winnipeg


TAPER BEARING ELIMINATES ALL SIDE-PLAY
BALL BEARING GIVES FRICTION WITHOUT BINDING

SHAFT
CONSTRUCTION
Patented
May 13, 1924

LOMBARDI

Straight-Line-Frequency Condenser



**LOMBARDI
JUNIOR**

Midget Condenser for Balancing Stages of Multiple Controlled Radio Frequency, for Capacity Antenna Coupling and Tuned Tickler Regeneration

Lombardi Straight-Line-Frequency Condensers give sharp tuning and separation of low wave stations not possible with any other type. Made with highest mechanical and electrical precision. Absolute minimum of loss and variation from rated capacity. Patented adjustable ball and taper shaft bearings eliminate all play in rotor. Watch spring pigtail makes positive contact. Made in single or multiple units. Multiple Condensers licensed under Hogan patents.

Recommended in August "Popular Radio" for use in Craig Tuned Radio Frequency Set

LOMBARDI RADIO MANUFACTURING COMPANY
67 MINERVA STREET, DERBY, CONN.

First in the Field Specializing in Cockaday Kits

S. HAMMER RADIO CO., 303 Atkins Ave. Brooklyn, New York

Cockaday Sets Now Made Easier to Build by Our New "Ready-to-Wire" Plan

50% of Your Time, Work and Worry SAVED!

All you need do is to connect bus-bar according to diagram, solder and your set is finished.

These Kits are sent to you completely mounted, and assembled on a Veneered Mahogany baseboard and genuine bakelite panel, drilled and engraved; in a solid Mahogany Cabinet. Genuine parts used as listed below; exactly as specified by Mr. L. M. Cockaday. COMPARE OUR OFFER!

8 TUBE NEW SINGLE DIAL CONTROL SUPERHETERODYNE

2	Precise No. 750 Syncrodensers .0005	$9.00
1	Precise No. 744 Coupler	.60
2	Precise Aluminum Brackets pr.	2.00
1	Precise No. 1900 Filtoformer.	4.50
1	Precise No. 1700 Super Multiformer	20.00
2	Precise Audio Transformers No. 480—5 to 1 and 2½ to 1.	15.00
1	Marco 4 inch Vernier Dial	2.50
1	Hammarlund, Jr., Midget	1.80
2	Carter Imp. Jacks	1.00
1	Carter Holdtite Do. Jack	1.00
1	Carter Holdtite Single Jack	.70
1	Benjamin No. 9050 8-gang socket shelf	11.00
1	Benjamin Battery Switch	.35
1	Weston No. 301 Volt Meter	8.00
1	Weston No. 301 Milliammeter	8.00
1	N. Y. Coil fixed condenser .006	$.75
1	N. Y. Coil fixed condenser .00025	.35
2	Dubilier 1. Mfd. By-Pass condensers	2.50
1	Dubilier No. 640 fixed condenser .00025 clips	.45
1	Daven grid leak 2 meg.	.50
1	Precision Inducto coupler No. 260	1.85
1	Gen. Radio 2 Ohm Rheostat No. 214-A	2.25
1	Gen. Radio 400 Ohm Pot. No. 214-A	3.00
1	Genuine Bakelite Panel Drilled and Engraved 10" x 14½" x 3-16"	4.35
	Wire, screws, etc.	

READY-TO-WIRE KIT, PRICE, . $101.45

UNASSEMBLED KIT, PRICE, Write Us

WIRED COMPLETE In Genuine Mahogany Cabinet . **$115.00**

D. T. W. LOOP IN STOCK

Cockaday's New LC-26 Receiver

1	General Radio Variometer type 269 with rheostat knob	$5 30
1	General Radio Rheostat type 214-a, 7 ohms, with rheostat knob	2.25
1	Precision Octaform coil set	5.50
1	Amsco Double Unit Condenser No. 1814	6.25
1	Micamold fixed Condenser .00015 mfd.	.35
1	Micamold fixed Condenser .00025 mfd.	.35
2	Daven resisto-couplers (new type)	3.00
1	Amertran DeLuxe transformer, first stage	10.00
	Bradleyleak ¼ to 10 meg.†	1.85
3	Bradleyunits, ¼ megohm	2 25
1	Bradleyunit ½ megohm	.75
3	Amperites No. 1a	3.30
1	Amperite No. 112	1.10
5	Benjamin standard "Cle-ra-tone" sockets	5 00
1	Carter single-circuit jack No. 101	.70
2	Carter Jack switches No. 2	2.00
8	Eby binding posts	1.20
1	Fynur vernier control knob and dial	3.50
1	Universal decorated panel, 8 x 22 inches	7.50
4	Small brass brackets	
2	Bakelite Connection Blocks 1 x 2 plus 1 x 9	
2	Large Brass Brackets	

READY-TO-WIRE KIT, PRICE, . $62.15

UNASSEMBLED KIT, PRICE, Write Us

WIRED COMPLETE In Genuine Mahogany Specified Cabinet **$80.00**

HAMMARLUND ROBERTS KITS IN STOCK!

WRITE FOR BOOKLET about these Parts and Kits. *Also for Free Radio Catalog*

Transportation Prepaid. One-third must accompany all C. O. D. orders. Not insured unless insurance charges included

Refine Your Receiver
with one of these dials

ACCURATUNE

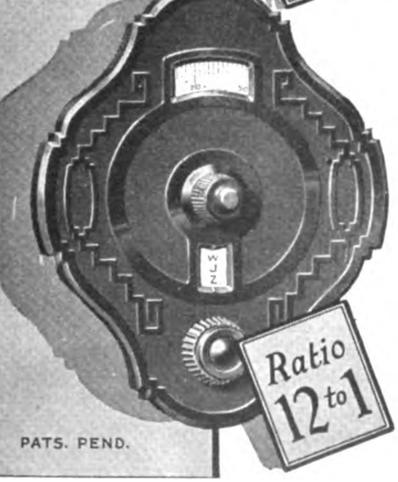
ACCURATUNE dials not only enhance immeasurably the attractive appearance of your set but they insure clear and precise reception of programs, and with even those stations now so closely grouped on the lower wave lengths easily and readily segregated. This type recommended for Neutrodyne and Radio Frequency sets.

Priced at $3.50

A. J. VERNIER

FOR use on Super-Heterodyne and Regenerative receiving sets, the A. J. offers a degree of tuning efficiency not usually associated with dials that sell at this price. Beautifully constructed of genuine Bakelite, the A. J. possesses a dignity of appearance that lends an air of richness to your receiver.

Priced at $2.25

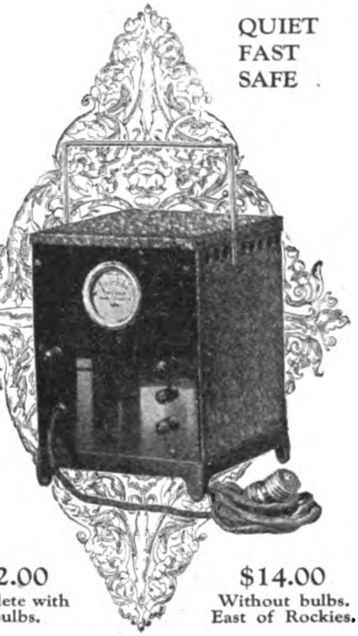


Recording Dial

ON this new style recording dial, *ample* space has been provided to jot down call letters, thus insuring a permanent record of dial settings. The dial itself is beautifully proportioned, made of genuine Bakelite with handsome embellishments on a matted background. Truly a product of master craftsmen who specialize in the manufacture of dials.

Priced at $1.75

MYDAR RADIO·CO.
5 CAMPBELL ST., NEWARK, N. J.



$22.00
Complete with
2 bulbs.

$14.00
Without bulbs.
East of Rockies.

Points to Remember When Selecting a Battery Charger

THERE are several vital factors to consider.

(1) Select an up-to-date charger that is guaranteed by a reliable company. (2) That will charge quietly. (3) at a fast rate (4) with no danger of overcharging or discharging the battery. (5) That is safe (6) dependable (7) easy to use (8) economical (9) and attractive in appearance.

The new Twin Bulb HANDY CHARGER is the latest improvement in battery chargers, made and guaranteed by the largest exclusive manufacturers of battery chargers—the Interstate Electric Company. It charges without the slightest noise and cannot overcharge or discharge the battery. A very economical and fast rate of charging is assured by the advanced "push-pull" principle that uses *both* halves of the AC wave at a speed of from 4 to 5 amperes. Adapted to "A" batteries of from 2 to 12 volts. "B" batteries from 24 to 120 volts in series. No extra attachments necessary. It charges them all, is easy to use and is practically trouble proof.

"Batteries are the only true source of noiseless current for radio reception"

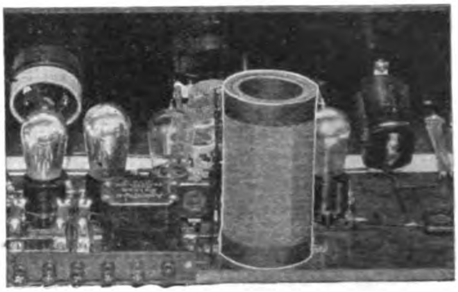
The New TWIN BULB

HANDY CHARGER

MANUFACTURED BY

INTERSTATE ELECTRIC CO.

4337 Duncan Ave. St. Louis, U. S. A.



The Precision Octaform Coil

shown above is the only coil that can be used in Mr. Cockaday's new LC-26 Receiver. Price $5.50.

The Cockaday LC-26 Receiver Kit

For the convenience of those consumers and dealers who wish to buy the Cockaday LC-26 in complete kit form we offer the following parts exactly as used in Mr. Cockaday's laboratory model.

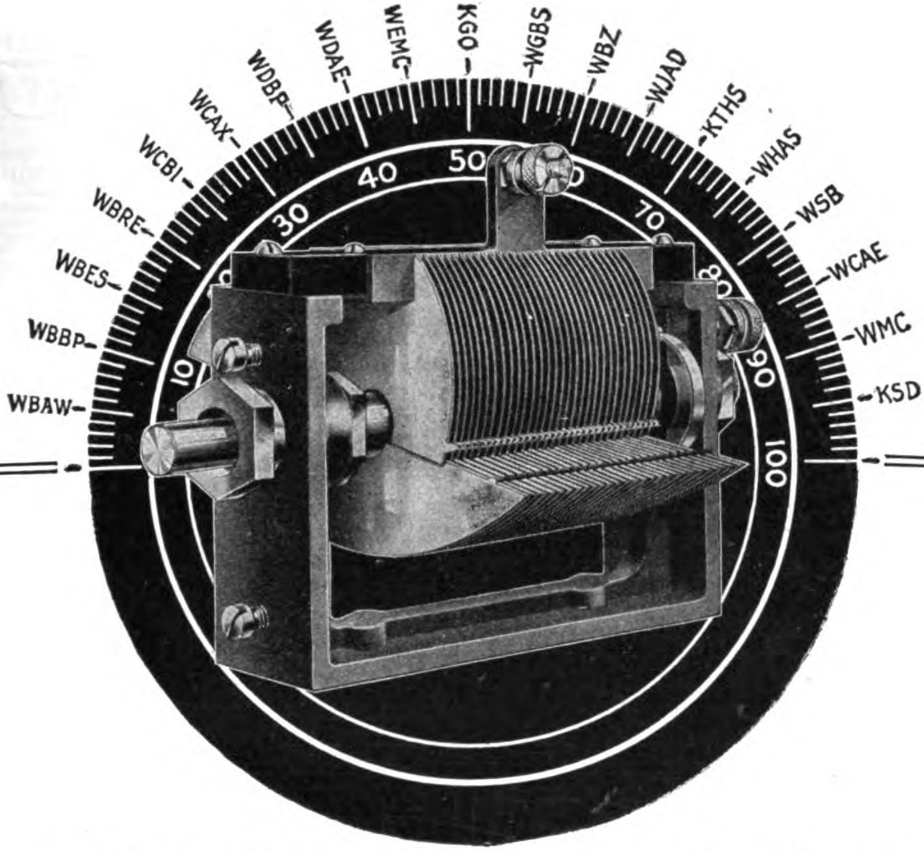
1 General Radio variometer, type 269, equipped with rheostat knob	$5.30
1 General Radio rheostat, type 214-a, 7 ohms, equipped with rheostat knob	2.25
1 Precision Octaform coil set	5.50
1 Amsco special double unit condenser No. 1814 each section .0003 mfd.	6.25
1 Micamold fixed condenser, .00015 mfd.	.35
1 Micamold fixed condenser, .00025 mfd.	.35
2 Daven resisto-couplers (new type which incorporates .1 mfd. condenser concealed in base)	3.00
1 Amertran DeLuxe transformer, first stage	10.00
Bradleyleak, ¼ to 10 meg.	1.85
3 Bradleyunits, ¼ megohm	2.25
1 Bradleyunit, ⅕ megohm	.75
3 Amperites No. 1a	3.30
1 Amperite No. 112	1.10
5 Benjamin standard "Cle-ra-tone" sockets	5.00
1 Carter single-circuit jack, No. 101	.70
2 Carter Jack switches, No. 2	2.00
8 Eby binding posts	1.20
1 Fynur vernier control knob and dial	3.50
1 Universal decorated panel, 8 x 22 inches	7.50
Blueprints	1.00
4 Small brass brackets	
1 Antenna connection block, 1 x 2 inches	
1 Battery connection block, 1 x 9 inches	1.75
2 Large brass brackets	
Screws and buss wire	
Solid Walnut Cabinet	17.00
Total	$81.90

Parts for the Cockaday "B" Eliminator (Raytheon Plate Supply Unit) may be obtained exactly as specified in November POPULAR RADIO—Price $42.05.

Dealers—Write for information on Coils and Kits.

Precision Coil Company, Inc.

209 Centre St. New York, N. Y.



Smallest Uniform Frequency Condenser

Easily Fits Into Present Sets

FULL size illustration above shows Samson Condensers are but 2¼″ diameter with plates fully extended—half to a third the size of others.

You can easily increase the selectivity of your present receiving set having ordinary condensers, and do away with the crowding of station readings—where 85 out of 100 come in below 50 on dial—by using

Samson
Uniform Frequency
Condensers

Samson Uniform Frequency Condensers are built to a tolerance of 1/1,000 inch, silver plated all over for high surface conductivity, and—in addition—have gold plated rotor and stator plates to prevent oxidization.

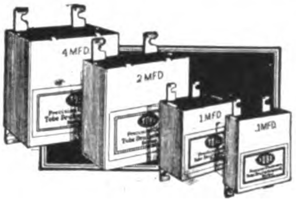
These grounded rotor type instruments have losses lower than the average laboratory standards. This condenser, due to its design, does not have the defects caused by either solid metal or dielectric end plates. 500 mmf., $7.00; 350 mmf., $6.75; 250 mmf., $6.50.

SAMSON ELECTRIC CO.
Manufacturers since 1882
Canton, Mass.
Sales Representatives in Thirty Leading American Cities

MEMBER R.M.A.

Fine Radio **TOBE** *Apparatus*

DEUTSCHMANN



FILTER CONDENSERS—

enthusiastically endorsed by the leading Radio authorities!

Made in the following capacities:

.1 MFD	Type 705	$ .70
.25 MFD	Type 706	.75
.5 MFD	Type 707	.90
1. MFD	Type 708	1.25
2. MFD	Type 709	1.75
3. MFD	Type 710	2.75
4. MFD	Type 711	3.75
5. MFD	Type 712	4.50

TOBE condensers were specified in "How to Build" articles in the November issues of *Radio News*, POPULAR RADIO, *Radio Broadcast* and *Radio*. Such unanimous approval has seldom, if ever, been awarded to any radio apparatus. TOBE condensers received this tremendous endorsement ⟶

Ask for TOBE Condensers

First—Because of their uniformity (less than 5% variation from rated capacities).

Second—Because of their permanence (their rigid construction assures permanence of rated capacities through variations of temperature).

Third—Because of their high megohm resistance (indicating extreme low-loss and high insulation).

Fourth—Because of their capacity to withstand overload (can operate at voltages up to 700 D.C. without breakdown).

D.T.W. LOOP

(Collapsible)

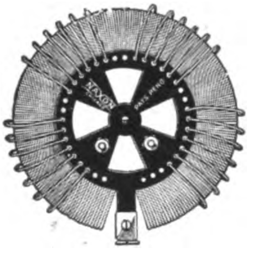
The one loop selected—in all America—by McLaughlin for his single control Superheterodyne. Electrically supreme. Large size 27 inch sides. Genuine Litz with spacing permanently assured. No dead ends. Graduated base for compass settings. Low R. F. resistance. Ideal for loop regenerative sets. See it at your dealers.........

$25.00

TOBE DEUTSCHMANN COMPANY

CORNHILL, BOSTON, MASS.

Price $4.00 Each



$12.00 Set of Three

NAXON

Toroidal Transformers

Seven Points of Superiority

1. Correctly distributed external primary.
2. Absence of usual secondary eddy-current losses.
3. Maximum magnetic coupling with minimum capacity coupling.
4. Sturdy construction without coil housings to absorb energy.
5. Spaced low-resistance windings.
6. Silver plated primary reduces skin losses.
7. Each turn a perfect toroid. No trick-style windings with losses at every angular bend.

Naxon Electrical Laboratories
Inductance Research Division
4524-26 Cottage Grove Avenue, Chicago

Money Flows
Where the Crowd Goes—

Become an Amplitron Headquarters
Keep Your Cash Register Busy All Day

THE

AMPLITRON

A Type for Every Circuit **Amplifier Detector**

Dealers—Jobbers
Line Up With the Fastest Selling Tube on the Market—

A LONG LIFE TUBE

The utmost achievement in Tubes, 100% performance a certainty. Superior Quality—Service—Tone Selectivity and Volume of Amplitron have convinced the Fan of its merits—A Real Sale Booster. A Guarantee without red tape—Liberal and co-operative Sales Policy—Get in line—

"Bonded to Give Service"

Clear Your Shelves of "dead ones"
Get into Action with "Live Ones"

List Price $2.50 Liberal Discounts

A Number of Excellent Territories Still Open

Pennant Radio Laboratories
57-63 HOYT ST. NEWARK, N. J.

Everyone Interested in RADIO Should Write for this FREE Radio Book

Guarantee
Every product is sold with the understanding that it is subject to the purchasers approval. If for any reason you are not fully satisfied return it to us and we will refund your money

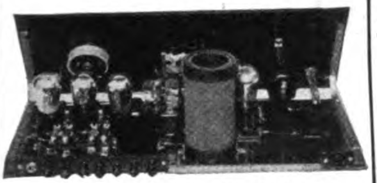
Write for Your **FREE** copy to-day

OUR NEW 96-PAGE CATALOG

The finest and most complete radio value book published is yours free. A post card brings you your copy—send for it Now—TODAY! When you buy from WRS, you save the jobbers' and retailers' double profit! In addition, it is "chockful" of interesting data every fan wants to know: Trouble Shooting Chart, Revised and Complete List of Broadcasting Stations, Log Chart, etc. ALL MERCHANDISE GUARANTEED. You MUST be satisfied or your money will be refunded. 24 hours service—orders shipped on same day received!

Announcing Immediate Delivery
Laurence Cockaday's

LC-26
Broadcast Receiver



Parts Used by Mr. Cockaday in Building His Laboratory Set

1 General Radio Variometer, type 269, equipped with rheostat knob
1 General Radio Rheostat, type 214-a, 7 ohms, equipped with rheostat knob
1 Precision Octaform coil set
1 Amsco special double unit condenser No. 1814, each section .0003 mfd.
1 Micamold fixed condenser, .00015 mfd.
1 Micamold fixed condenser, .00025 mfd.
2 Daven resisto-couplers (new type which incorporated 1 mfd. condenser concealed in base)
1 Amertran DeLuxe transformer, first stage
1 Bradleyleak ¼ to 10 meg.
3 Bradleyunits ¼ megohm
1 Bradleyunit ½ megohm
3 Amperites No. 1a
1 Amperite No. 112
5 Benjamin standard "Cle-ra-tone" sockets
1 Carter single-circuit jack, No. 101
2 Carter Jack switches, No. 2
8 Eby binding posts.
1 Fynur vernier control knob and dial
1 Universal decorated panel, 8 x 22 inches
1 Baseboard
4 Small brass brackets
1 Antenna connection block, 1 x 2 inches
1 Battery connection block, 1 x 9 inches
2 Large brass brackets
1 Box of assorted screws, consisting of screws, lugs, nuts, etc.
30 Feet brass wire
8 Feet of tubing
1 Set of Popular Radio reprints

WRITE FOR SPECIAL KIT PRICE

SPECIAL CIRCULAR

Containing full information about this set with special price offer, etc., sent FREE ON REQUEST

FREE

POSTAGE FREE with all orders over $5.00

YOUR SATISFACTION INSURANCE

Our MONEY-BACK Guarantee is your absolute insurance of thorough satisfaction. Your money is still YOUR MONEY until you are thoroughly satisfied. Money refunded without question or quibble.

COMPLETE KITS

RAYTHEON

PLATE SUPPLY UNIT

IMMEDIATE DELIVERY

Complete information in our new catalog. Write for it today

NEW
SILVER MARSHALL
6 Tube Receiver

Featured in our newest guide-book. A postal brings you a copy. No obligation.

COMPLETE PARTS for the

McLaughlin Single Control Superheterodyne

All parts exactly as specified by Mr. McLaughlin. In our new catalog—prices, details, etc.

WE SPECIALIZE

In EVERY circuit approved by the technical engineers of RADIO BROADCAST, Mr. Cockaday and other leading radio authorities, Cockaday Super, Cockaday DX, Ultradyne, Superdyne, Pressley Reflex, Reflex, etc.

Complete Parts for the NEW

Hammarlund Roberts
RECEIVER

ENDORSED BY TEN LEADING ENGINEERS

The ONE non-radiating receiver with sensitivity of the superheterodyne. Razor blade selectivity even in crowded areas. Tuning reduced to the simplicity of two major controls. Automatic filament control, superb tone plus the entire elimination of distortion.

The parts listed below are exactly as specified by the originators of this circuit

2 Rauland Lyric Transformers
1 Hammarlund Midget Condenser
2 Hammarlund .0005 mfd. Straight Line frequency Condensers
1 Set Hammarlund Roberts Coil
2 Alden "Super DeLuxe" Sockets
5 Alden DeLuxe Sockets
1 Alden K-3843 1¾-inch Dial
4 Amperites No. 1-A
5 Prs. Union Phone tip jacks
1 Carter 25 ohm "Imp" Rheostat
1 Carter Single circuit No. 101 "Hold-tite" Jack
1 Carter "Imp" Battery Switch
1 Dubilier Type 640-G .00025 mfd. Grid Condenser
1 Dubilier Type 640 .002 mfd. Fixed Condenser
1 Dubilier Type 640 .006 mfd. Condenser
1 Durham Resistor
1 Hammarlund-Roberts Foundation Unit

WRITE FOR CATALOG FOR DESCRIPTION AND PRICE

FREE A copy of our radio Guide Book and Catalog should be in every fan's library. It's chockful of interesting data and hundreds of exceptional radio values. A postal brings it. Be sure to address Room 102 **DO IT NOW**

WHOLESALE RADIO SERVICE CO.

Manufacturers and Wholesale Distributors of Radio Apparatus
Be sure to address ROOM 102
6 CHURCH STREET - - - NEW YORK CITY

THE TUBE WITH A SENSIBLE GUARANTEE

If someone wants to give you something for nothing.............................*hesitate*
If someone wants to sell you something too cheap...............................*hesitate*
If someone wants to sell you a radio tube—with an unlimited guarantee, and without means of identification.............................*hesitate*
SUPERTRON is reasonably guaranteed. Each tube serial numbered—identified by a guarantee certificate, for your protection—for your satisfaction.

Buy Safe—Buy Supertrons
Avoid Cut Price Stores

All Types $2.00

Canada $2.75

DISTRIBUTORS

C. E. Niehoff & Co.	**Chicago**
Fireside Radio Set Co.	**Chicago**
Yahr & Lange	**Milwaukee**
The Roycraft Co.	**Minneapolis**
Hippee-States Auto Sup.	**Des Moines**
Sorenson Lamp Co.	**Des Moines**
Orr Bros	**Cedar Rapids**
Radio Dealers Sup. Co.	**San Francisco**
Franklin Electric Supply Co	**Philadelphia**
Keystone Radio Dist. Co.	**Philadelphia**
Swanson Electric Co.	**Evansville**
M. H. Johnson Electric Co	**Utica**
Hinsdill Electric Co.	**Troy**
Iroquois Sales Co.	**Buffalo**
Hamburg Bros	**Pittsburgh**
Radio Stores Inc	**Denver**
Reynolds Radio Co	**Denver**
Burr-Fowler	**Syracuse**
Ed. J. Goetz Co	**Cincinnati**
American Radio & Supply Co	**Cincinnati**
Elgin Radio Corp	**Elgin**
Alberta Radio Co	**Alberta, Canada**
Imperial Radio Co.	**Sault Ste. Marie, Can.**
F. X. Guillevin	**Montreal, Can.**
Turner Lippee	**Newark, N. J.**
Herbrick-Lawrence	**Nashville**
Banner Accessories Co.	**St. Louis**
Witte Hardware Co.	**St. Louis**
J. W. Jenkins Sons Music Co.	**Kansas City**
E. S. Cowis Electric Co.	**Kansas City**
Specialty Service	**Brooklyn**
G. J. Seedman	**Brooklyn**
H. Brownlow	**Springfield, Mo.**
Hillman's Inc.	**Augusta, Me.**

Branch Offices

ATLANTA	**Georgia Savings Bank Bldg.**
DALLAS	**2006½ Commerce St.**
PHILADELPHIA	**353 No. 4th St.**
CHICAGO	**53 W. Jackson Blvd.**
PITTSBURGH	**Federal Reserve Bldg.**
DETROIT	**714 Lafayette Bldg.**
MINNEAPOLIS	**229 So. 4th St.**
KANSAS CITY	**3955 Mercer Ave.**
DENVER	**1641 Stout St.**
BUFFALO	**293 South Elmwood**
BOSTON	**99 Bedford St.**
OMAHA, NEB.	**625 Securities Bldg.**
LOS ANGELES	**3268 Glendale Blvd.**
PORTLAND	**997 Forest Ave.**
TOLEDO	**Summit-Cherry Bldg.**
ST. LOUIS	**1627 Chemical Bldg.**

SUPERTRON MFG. CO., Inc.

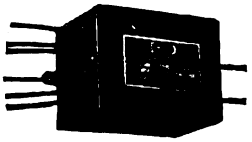
HOBOKEN, NEW JERSEY
Export Department 220 Broadway, N. Y. C.

SUPERTRON
A SERIAL NUMBER GUARANTEE

DONGAN

Transformers and Chokes Share in Big Demand for New B-Eliminators

Are you one of those radio lovers who have waited patiently for a perfected B-Eliminator? Because the new type Filament and Non-Filament Tubes have definitely answered the problem. With these tubes you can build a perfected B-Eliminator that improves your radio enjoyment more than you have thought possible.

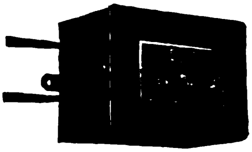


Dongan Transformers and Chokes are important parts in the construction of these remarkable new B-Eliminators.

Transformers

Type No.				
509	Full wave	For Raytheon Tubes		
537	Full wave	For R.C.A.	U X 213	Tubes
537	Full wave	For Cunningham	C X 313	Tubes
538	Half wave	For R.C.A.	U X 216-B	Tubes
538	Half wave	For Cunningham	C X 316-B	Tubes

List $7.00

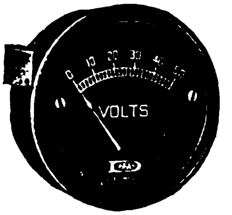


Chokes

Type No.	
514	20 henry
506	30 henry
539	50 henry

List $5.00

Voltmeters that are Accurate



You must have a voltmeter that is accurate to keep your battery and tube voltage up to par—which means consistently good reception. Dongan Voltmeters are really accurate.

TYPE N

0-7 Volts	**$1.75**
0-50 Volts	**$1.75**
0-100 Volts	**$2.00**

Instructions on building your own B-Eliminator sent free on request. Dongan quality radio products at most dealers. Money orders filled promptly.

Set Manufacturers

Dongan Audio Transformers are the accepted standard among Set Manufacturers. For quality products and a fair price you cannot equal Dongan Audio Transformers. Quotations on request.

DONGAN ELECTRIC MANUFACTURING CO.
2983 Franklin St. Detroit, Mich.

"Transformers of Merit for 15 years"

Volumes of praise for the Tone Quality
The fully balanced unit

The R. F. I. Speaker

Licensed under the Lecktofone patents

ASK
YOUR
DEALER

Price
$22.50

Radio Foundation, Inc.
25 WEST BROADWAY NEW YORK, N. Y.

ANYONE CAN BUILD A SET WITH *SIMPLIFIED BLUEPRINTS*

LAURENCE M. COCKADAY has personally supervised the preparation of *Simplified Blueprints* of eight of POPULAR RADIO's most popular circuits. Each set consists of at least three separate *Actual Size* Blueprints; first a Panel Pattern; second, an Instrument Layout; and third, a Picture Wiring Diagram all simplified in the fullest sense of the word ***because***

The Panel Pattern can be laid on the panel and all holes drilled as indicated. No scaling to do and so accurate there is no danger of ruining the panel through faulty calculation.

The Instrument Layout placed on the sub-base permits you to indicate by pinpricks the exact location of every screw.

The Picture Wiring Diagram gives every instrument in exact size and position with every wire clearly indicated from one contact to the other. With no knowledge of radio symbols you can assemble every part and complete your wiring with no chance of error.

Priced at $1.00 per Set of Three Prints

Set No. 4—"*Cockaday Four-Circuit Tuner with Resistance-Coupled Amplifier*" (five tubes, distortionless, two dials, automatic vacuum tube control, as described in the October, 1924, issue of POPULAR RADIO).

Set No. 6—"*The Cockaday 8-tube Super-heterodyne Reflex Receiver*" (eight tubes, two tuning dials, loop, non-radiating, distortionless, as described in January, 1925, issue of POPULAR RADIO).

Set No. 7—"*The Craig 4-Tube Reflex Receiver with the New Sodion Detector*" (four tubes, two tuning dials, short antenna, non-radiating as described in February, 1925, issue of POPULAR RADIO).

Set No. 9 — "*Portable Town and Country Receiver*" (six tubes, three stages of transformer coupled, radio-frequency amplification, loop antenna, tuned by variable condenser as described in May, 1925, issue of POPULAR RADIO.)

Set No. 11—"*5-Tube Tuned Radio-Frequency Receiver with Simplified Control*" (as described in August, 1925, issue of POPULAR RADIO).

Set No. 12—"*8-Tube Superheterodyne with Single Control*" (eight tubes, two straightline variable condensers, as described in October, 1925, issue of POPULAR RADIO).

Set No. 13—'*Ratheon Plate Supply Unit*" (a really dependable method for obtaining a "B" source of supply as described in November, 1925, issue of POPULAR RADIO).

Set No. 14—"*The LC-26 Broadcast Receiver*" (as described in December, 1925, issue of POPULAR RADIO).

Full constructional and parts details for these Receiving Sets will be found in the issue of POPULAR RADIO indicated. Back issues of POPULAR RADIO will be furnished at the rate of 35c a copy

Popular Radio

627 West 43d Street **Dept. 124** **New York City**

POPULAR RADIO, Inc., Dept. 124
627 West 43d St., New York City Date....................................

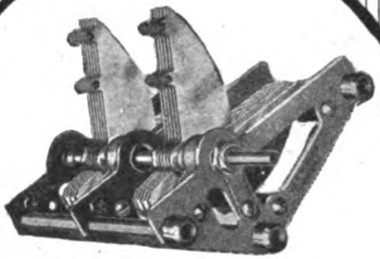
Enclosed is my remittance of $.................., for which kindly send me Blueprint Set (s) consisting of Panel Pattern, Instrument Layout and Wiring Diagram as checked below:

☐ **Set Number 4** ☐ **Set Number 9**
☐ **Set Number 6** ☐ **Set Number 11**
☐ **Set Number 7** ☐ **Set Number 12**
☐ **Set No. 13**
☐ **Set No. 14**

Name..
Address..
City.................................... State....................

DEALERS

Write for terms on these fast selling Blueprints. An attractive Display Chart free with orders.



Made under Hogan Patent No. 1,014,002
Jan. 9. 1912

NEW!

Straight Line Frequency Condensers

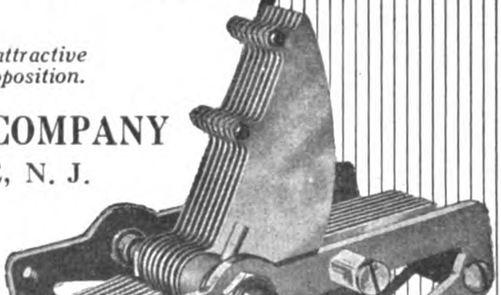
The newest development in Radio is Straight Line Frequency Condensers for better reception and more accurate tuning.

Your customers are interested in selectivity and the new U. S. Tool Straight Line Frequency Condensers give the highest degree of selectivity yet achieved.

Made by the largest makers of quality condensers with whom the manufacture of fine condensers is an art.

Write for attractive Dealer Proposition.

U. S. TOOL COMPANY
AMPERE, N. J.



Never before used in DIALS!

The Mechanical Principle in

GEE-HAW

Ratio 100 to 1 No Backlash

GEE DIAL HAW Micrometer Tuning DIAL

The true value of these DIALS to any set is "Indescribable
GEE-HAW DIALS *are the* "THAT"
which makes set function 100%

Proven by Test
Supreme Master
for Sharp Tuning

See Demonstration

If the use of the GEE HAW DIAL does not materially improve the selectivity of any radio set on which it is installed, it may be returned to us (accompanied by bill of sale from dealer) and purchase price refunded without question or argument. Does any other manufacturer of dials *dare* duplicate this offer? Price $3.00.

OTTO R. GISCHOW Co. INC. 125 West 51st St
NEW YORK CITY

$4.75

APOLLO

A loud speaker of surprising musical quality and volume. In a class with the high priced speakers. Artistically designed. Swan neck type. Adjustable unit where volume and tone are at all times under control.

Send no money, just pay the postman.

RIX RADIO

SUPPLY HOUSE, INC.
5505 4th Ave., Dept. 44, Brooklyn, N. Y.

RADIO MANUAL FREE

WITH

POPULAR RADIO

Kendall Banning, Editor, and **Laurence M. Cockaday,** Technical Editor of POPULAR RADIO, have compiled a book that will prove to any one that he can build a set which will give distance, selectivity and tone volume, and at the same time a very definite basic knowledge of radio.

BUILD YOUR OWN SET AND SAVE MONEY

In "How to Build Your Radio Receiver," you will find complete specifications, constructional diagrams, photographs and instructions for building all of the following sets:

A $5 Crystal Set
The Haynes Single-Tube Receiver
A Two-Stage Audio-frequency Amplifier
The Cockaday 4-Circuit Tuner
A 5-Tube Tuned Radio-frequency Receiver
The "Improved" Cockaday 4-Circuit Tuner
The Regenerative Super-Heterodyne Receiver

ADVISORY SERVICE ALSO FREE

POPULAR RADIO maintains a big modern laboratory with a trained staff of investigators under the personal supervision of Mr. Cockaday. This Laboratory is always available through our Technical Service Bureau to answer, free of charge, by personal letter any problems you encounter which are not answered in either the "Handbook" or the magazine.

In POPULAR RADIO each month you will find the very latest news of the radio field as well as helpful suggestions and instructive and entertaining articles on radio and allied scientific phenomena.

SPECIAL BOOK OFFER

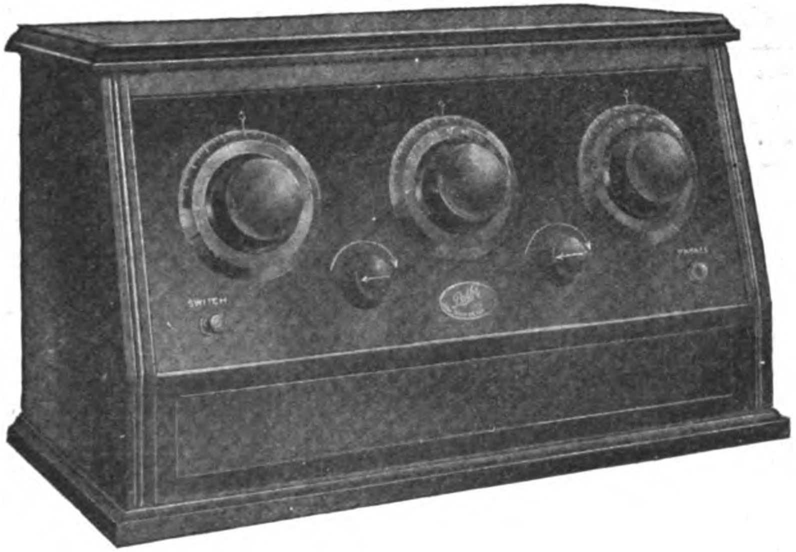
You can secure a copy of "How to Build Your Radio Receiver" FREE, and have all the privileges of the Technical Service Bureau without additional expense, if you will send a remittance of $3.00 in full payment of 12 months' subscription for POPULAR RADIO. (Or as an alternative, you may have the book and privileges of the Technical Service Bureau with POPULAR RADIO for 7 months only—for $2.00. A two dollar bill will do.)

Remember you take no chance—we will refund your money in full if you are not more than satisfied.

POPULAR RADIO
Dept. 125
627 West 43d Street New York City

Pathé
REG. U.S. PAT. OFF.

UNIVERSAL FIVE



Price
$65.00
without equipment

Equipped to use

New McCullough AC Tubes
Gives Highest Efficiency
No A (*wet*) Batteries Required

PATHÉ PHONOGRAPH & RADIO CORPORATION
20 GRAND AVENUE **Dept. P49** **BROOKLYN, N. Y.**

The Christmas Gift Supreme

There is an appropriate magazine for every friend on your Christmas list

POPULAR RADIO Two annual subscriptions $5.00

Additional one year gift subscriptions only $2.50

*Judge *Popular Radio $8.00 Reg. For........... **$5.50**	*Cosmopolitan *Good Housekeeping Popular Radio $9.00 Reg. For............ **$7.50**	Film Fun *Judge *Popular Radio $10.00 Reg. For............ **$7.35**
Pictorial Review Modern Priscilla Popular Radio $6.50 Reg. For........... **$5.10**	McCall's Popular Radio $4.00 Reg. For........... **$3.50**	*Judge *Film Fun *Wit of the World $10.00 Reg. For........... **$8.00**
Today's Housewife McCall's Popular Radio $4.50 Reg. For............ **$3.75**	*American Magazine *Woman's Home Companion Popular Radio $7.00 Reg. For............ **$5.75**	Success Popular Radio $5.50 Reg. For............ **$4.00**

• Combinations starred (*) must go to one address.

The most expensive gift you might select will be no more appreciated than a relatively inexpensive subscription for a good magazine. And the magazine by its arrival at regular intervals will keep the holly green throughout the year and serve as a constant reminder of your friendly thought.

Check off now a list of your friends who are interested in radio. You can readily picture their delight on learning that POPULAR RADIO is to be sent to them for a year as your gift. Just dot down their names and addresses now for a starter. The cost is only $2.50 each on this Christmas Special and you couldn't possibly please them more.

For each of your other friends there is an appropriate magazine that you can select from the many listed. Just complete your list and note the surprisingly low cost at which you have remembered all of your friends.

CHRISTMAS GREETING CARDS

A handsome Greeting Card will be mailed to reach each gift subscriber on Christmas morning, stating that the magazine you order is being sent for a year as your gift.

Merely fill out the handy coupon below, attach it to a list giving the name, address and magazine you wish each to receive (your own subscriptions, too), and we will take care of all details promptly. Please don't delay, as orders placed now are assured of early attention.

This offer not good after December 31, 1925.

POPULAR RADIO

627 West 43d Street, New York City, N. Y.

POPULAR RADIO, Dept. 122,
627 West 43d Street,
New York City, N. Y.

Date................1925

Enclosed remittance of $.......... is payment in full for the magazines ordered on the attached list. See that a Greeting Card reaches each on Christmas morning announcing the magazine as my gift for the coming year.

Name..

Street and Number..

City..State..................

(If not a NEW subscription, please mark R after the name of the magazine, to indicate RENEWAL.)

Prices for Canada and foreign countries will be quoted on request.

MAKE any selection you wish from the following list, to be sent to different addresses if desired. Remit only the amount shown in the right-hand column, *if more than one magazine is ordered.* All quotations cover twelve issues to the year unless otherwise specified. POPULAR RADIO may be added to any combination of right-hand figures at $2.50 for each yearly subscription.

American Magazine..........	reg.	$2.50	for	$2.50
Atlantic Monthly...........	"	4.00	"	4.00
Baseball Magazine..........	"	2.00	"	1.75
Century Magazine...........	"	5.00	"	4.00
Christian Herald (52 issues)...	"	2.00	"	1.75
Collier's Weekly (52 issues)..	"	2.00	"	1.75
Cosmopolitan Magazine (Hearst's International)....	"	3.00	"	2.75
Delineator.................	"	2.00	"	1.50
Designer...................	"	1.50	"	1.10
Etude (Music Magazine).....	"	2.00	"	1.75
Field and Stream...........	"	2.50	"	2.25
Film Fun...............	"	2.00	"	1.85
Forbes Magazine (24 issues)...	"	5.00	"	4.50
Golden Book................	"	3.00	"	3.00
Good Housekeeping..........	"	3.00	"	3.00
Harper's Bazar.............	"	4.00	"	4.00
Harper's Magazine..........	"	4.00	"	3.50
House and Garden...........	"	3.50	"	3.25
House Beautiful............	"	3.00	"	2.75
Judge (52 issues)......	"	5.00	"	4.50
*Ladies' Home Journal......	"	1.00	"	1.00
McCall's Magazine..........	"	1.00	"	1.00
Modern Priscilla...........	"	2.00	"	1.75
Outlook (52 issues)........	"	5.00	"	5.00
People's Home Journal......	"	1.00	"	.90
Pictorial Review...........	"	1.50	"	1.50
Popular Radio..........	"	3.00	"	2.50
Popular Science Monthly.....	"	2.50	"	2.50
Q. S. T....................	"	2.00	"	1.85
Radio......................	"	2.50	"	2.00
Radio Broadcast............	"	4.00	"	3.50
Radio Digest (52 issues)......	"	5.00	"	4.50
Radio News.................	"	2.50	"	2.25
Radio World (52 issues).....	"	6.00	"	5.00
Review of Reviews..........	"	4.00	"	3.00
*Saturday Evening Post.....	"	2.00	"	2.00
Science and Invention.......	"	2.50	"	2.25
Screenland.................	"	3.00	"	2.00
Snappy Stories (24 issues)....	"	4.50	"	4.00
Success..		2.50	"	1.75
Sunset Magazine............	"	2.50	"	2.00
Theatre Magazine...........	"	4.00	"	3.75
Today's Housewife..........	"	.50	"	.50
Vogue (24 issues)..........	"	5.00	"	4.50
Wit of the World.......	"	3.00	"	2.50
Woman's Home Companion ..	"	1.50	"	1.50
World's Work...............	"	4.00	"	3.50

For Boys and Girls

American Boy...............	reg.	$2.00	for	$2.00
American Girl..............	"	1.50	"	1.40
Boys' Life.................	"	2.00	"	1.75
Boys' World (52 issues).....				.80
Child Life.................	"	3.00	"	2.50
Every Child's Magazine.....	"	1.50	"	1.25
Every Girl's (10 issues)......	"	1.00	"	.95
Everyland (10 issues)	"	1.50	"	1.40
Girls' Companion (52 issues)..				.80
John Martin's Book.........	"	4.00	"	3.50
Junior Home Magazine......	"	2.50	"	2.25
Kindergarten-Primary (5 issues)	"	.75	"	.70
Little Folks...............	"	2.00	"	1.75
St. Nicholas...............	"	4.00	"	3.50
Young People's Weekly (52 issues)...............				.85
Youth's Companion (52 issues)	"	2.00	"	2.00

*These magazines do not club but may be added to any combination at the price shown.

Perfect Precision!

Radio technicians and engineers as well as seasoned amateurs know that "General Instrument" is satisfied with nothing short of *perfect precision.*

For example: The General Instrument laboratories developed the eccentric type straight line frequency condenser at great expense—only TO ABANDON IT!

Try to rotate an eccentric type straight line frequency condenser and note the effect on the bearing and then you will realize why "General Instrument" discontinued the eccentric type and created the CONCENTRIC straight line frequency condenser.

CONCENTRIC straight line variable condensers represent the latest development in condenser engineering. Observe the even distribution of weight of the rotor plate.

"General Instrument" thinks more of its reputation than the cost involved in creating a perfect instrument. Hence—the CONCENTRIC straight line frequency condenser.

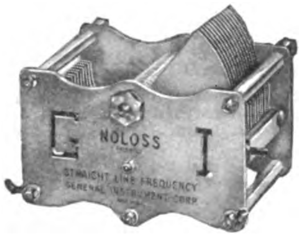
TYPE 80
STATOR

Concentric Straight Line Frequency Condenser

(Pyrex Insulated)

The perfect instrument created by General Instrument. Type 80.

TYPE 40



TYPE 80
Patented

The inimitable Rheostat

Built only by General Instrument, this rheostat can NOT be imitated. To get it, you must make sure of the name "General Instrument."

OBTAINABLE AT BETTER CLASS RADIO DEPARTMENTS

General Instrument Corporation
Manufacturers of Laboratory Equipment
423 Broome Street New York City

SIMPLIFIED BLUEPRINTS

FREE

You can have your choice of any one of six POPULAR RADIO Simplified Blueprints with your new or renewal subscription for POPULAR RADIO, accompanied by remittance of **$3.00.** These Blueprints will make it possible for you to build a tested and approved set, while POPULAR RADIO for 12 months will keep you in touch with the progress being made in radio.

You, as a reader of POPULAR RADIO, know the many entertaining, interesting and instructive articles that are published each month. Every issue some new item is sure to attract your attention. We promise that throughout the coming months POPULAR RADIO will hold more and more of interest for Radio Fans.

Ease, Economy and Accuracy in Construction

Simplified Blueprints were prepared under the personal supervision of Laurence M. Cockaday. They make it possible for anyone, without previous knowledge of radio, to construct a highly efficient radio receiver. Each set of Blueprints consists of at least 3 prints as follows:

Panel Pattern

This Blueprint is the EXACT size of the actual set. So accurate that you need merely lay it on your panel and drill as indicated. You can readily appreciate the convenience of this Blueprint. No scaling or measuring to do, no danger of ruining the panel through faulty calculation.

Instrument Layout

Here again you have an actual size print of each instrument and binding post and its exact location both on the panel and within the cabinet. Even the cabinet structure is clearly shown.

Wiring Diagram

The unusual feature of this Blueprint is that it is an actual size picture diagram of the finished set. Each instrument and other parts appear in exact size and the wires are so clearly traced from one contact to another that you can connect all terminals accurately without even knowing how to read a hook-up diagram.

Full constructional and parts details for these Receiving Sets will be found in the issue of POPULAR RADIO indicated. Back issues of POPULAR RADIO will be furnished at the rate of 35c a copy.

POPULAR RADIO
Department 129
627 West 43d Street, - New York

There Are Simplified Blueprints for the Following Sets:

Set No. 4—"*Cockaday Four-Circuit Tuner with Resistance-Coupled Amplifier*" (five tubes, distortionless, two dials, automatic vacuum tube control, as described in the October, 1924, issue of POPULAR RADIO).

Set No. 6—"*The Cockaday 8-tube Superheterodyne Reflex Receiver*" (eight tubes, two tuning dials, loop, non-radiating, distortionless, as described in January, 1925, issue of POPULAR RADIO).

Set No. 7—"*The Craig 4-Tube Reflex Receiver with the New Sodion Detector*" (four tubes, two tuning dials, short antenna, non-radiating as described in February, 1925, issue of POPULAR RADIO).

Set No. 9—"*Portable Town and Country Receiver*" (six tubes, three stages of transformer coupled, radio-frequency amplification, loop antenna, tuned by variable condenser as described in May, 1925, issue of POPULAR RADIO.)

Set No. 11—"*5-Tube Tuned Radio-Frequency Receiver with Simplified Control*" (as described in August, 1925, issue of POPULAR RADIO).

Set No. 12—"*8-Tube Superheterodyne with Single Control*" (eight tubes, two straightline variable condensers, as described in October, 1925, issue of POPULAR RADIO).

Set No. 13—"*Raytheon Plate Supply Unit*" (a really dependable method for obtaining a "B" source of supply as described in November, 1925, issue of POPULAR RADIO).

Set No. 14—"*The LC-26 Broadcast Receiver*" (as described in December, 1925, issue of POPULAR RADIO).

Use coupon below; indicate which set of Blueprints you want.

POPULAR RADIO, Dept. 129
627 West 43rd Street, New York City

Enclosed is my remittance of $........ in full payment for subscription, with Blueprints as checked below, FREE.

☐ **Set Number 4**
☐ **Set Number 6**
☐ **Set Number 7**
☐ **Set Number 9**
☐ **Set Number 11**
☐ **Set Number 12**
☐ **Set Number 13**
☐ **Set Number 14**

Name..

Street..

City..State...........

Speaking from Experience

The marked superiorities of tonal qualities in the Holtzer-Cabot Radio Loud Speaker are distinctly traceable to our fifty years specialization in the manufacture of fine electrical apparatus.

By comparison let your own ear be the judge, let your eye rest on the beauty of line, and let your judgment decide the security that this half century of stability lends to your purchase.

Ask your dealer to demonstrate a Holtzer-Cabot Speaker before making a choice of any kind.

National Loud Speaker

$12.00

Adjustable Control

1875-1925
For Fifty Years
Manufacturers
of Quality
Electrical
Apparatus

The Holtzer-Cabot Electric Co.
125 Amory Street
Boston, Mass.

Holtzer-Cabot

Only Two of Several "Ideal" Radio Consoles

PICTURED in this advertisement are only two of the several styles of radio consoles, cabinets and battery tables shown in the 1925–1926 "Ideal" catalog, which is now ready for distribution.

Ideal Radio Furniture is distinguished by graceful and harmonious design, clean-cut and well finished cabinet work and absence of over-ornamentation. Improved and greatly enlarged manufacturing facilities permit us to show one of the most varied selections of radio furniture now offered by any manufacturer.

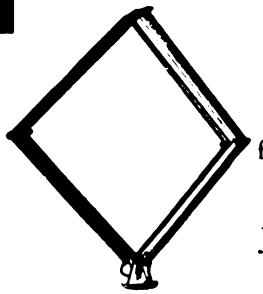
Remember we specialize in the manufacture of radio furniture only. We do not make receiving sets.

Write for Catalog if interested.

Ideal Radio Cabinet Co.

(not Inc.)

281 Vermont St. **Blue Island, Ill.**



SEND NO MONEY

for this Folding

LOOP

Just Your Name and Address.

WERNER LOOP ANTENNA

For use with any Type of Loop Receiver. Variable Inductance without the use of "Taps." Adjustable to a fine degree of Clearness.

A superior loop that does away with outdoor aerials and permits clearer reception. Can be folded or extended for use in an instant without the aid of any tool.

•APPROVED BY POPULAR RADIO LABORATORY•

New York Evening *World* says:

"After carefully testing this new device *The N.Y. Evening World* Radio Labotatory exclusively presents it to enthusiasts owning and operating loop receivers as an improvement over any type of loop they may now be using."

SEND FOR IT AT OUR EXPENSE

Send us your name and address and we will send a loop at our Expense. Pay Postman $14.00 and if not satisfied we will return your money.

WERNER TRANSFORMERS HIGHLY EFFICIENT

Used by those who know the best.

Radio Frequency	**$4**
Audio Frequency	**$6**

Booklet of circuit diagrams free on request.

WERNER RADIO MANUFACTURING CO.
204-206 NINTH STREET
BROOKLYN, N. Y.

Save 20 to 50%

FREE RADIO CATALOG

LATEST IN HOOK-UPS AND RADIO

The Barawik Company, mail-order pioneers in the merchandising of standard radio sets, parts and kits, offers you this season greater radio bargains than ever before. No matter what part, set or kit you want, we either have it or can get it for you at a guaranteed saving in price. Our stocks contain the greatest assortment of radio supplies ever gathered together by one organization. Be sure to get our free catalog and guide before you spend another cent. It will mean money in your pocket.

Shows thousands of bargains for anyone interested in radio, from complete sets to the smallest parts. Set builders, fans, beginners and those about to get a radio set for the first time, will find the Barawik Guide a goldmine of information. Just send us your name and address (also please include names of other radio fans) and we will send free copy at once.

Here are a few sample bargains from the Barawick Catalog:

Guaranteed 201A type Tubes	$1.15
Guaranteed 45-v. large B batteries	2.55
Complete parts for Remler-Best 8-tube Super	48.45
Complete parts for B-T Counterphase 6	63.50
Complete parts for Silver Super Autodyne	62.50
Complete parts for Hazeltine Neutrodyne	29.25
Complete parts for Browing-Drake circuit	32.25
Complete parts for McLaughlin 8-tube Super	82.50

Order direct from this ad or get a free copy of our complete catalog of everything in radio.

THE BARAWIK COMPANY

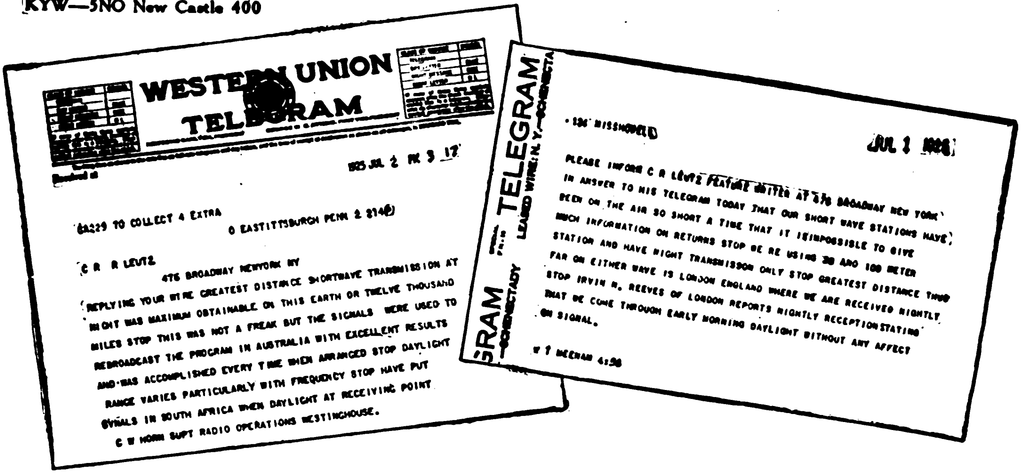
103-105 S. Canal St., Chicago, Ill.

UNIVERSAL PLIO-6

The Only Set That Tunes All Wave Lengths Within Distance Range

35 To 3600 METERS

3AR Melbourne 480—WGY 109—2FL Sydney 770—WKAQ San Juan 360—2BL Sydney 350—PCFF Amsterdam 2000 Karachi—Bombay—KOP—WGY 1660—6KW Tuinucu 340—Bankok—NSF Hilversum 1050—WLW—KDKA 64 KYW—5NO New Castle 400


WESTERN UNION TELEGRAM
Received at
TELEGRAM LEASED WIRE: N.Y.—SCHENECTA
GRAM —SCHENECTADY

1925 JUL 2 PM 3 17

6A229 TO COLLECT 4 EXTRA
O EASTPITTSBURGH PENN 2 214P

C R R LEUTZ
476 BROADWAY NEWYORK NY

REPLYING YOUR WIRE GREATEST DISTANCE SHORTWAVE TRANSMISSION AT NIGHT WAS MAXIMUM OBTAINABLE ON THIS EARTH OR TWELVE THOUSAND MILES STOP THIS WAS NOT A FREAK BUT THE SIGNALS WERE USED TO REBROADCAST THE PROGRAM IN AUSTRALIA WITH EXCELLENT RESULTS AND WAS ACCOMPLISHED EVERY TIME WHEN ARRANGED STOP DAYLIGHT RANGE VARIES PARTICULARLY WITH FREQUENCY STOP HAVE PUT SIGNALS IN SOUTH AFRICA WHEN DAYLIGHT AT RECEIVING POINT

C W HORN SUPT RADIO OPERATIONS WESTINGHOUSE.

136 NISSHORELD JUL 1 1925

PLEASE INFORM C R LEUTZ FEATURE WRITER AT 476 BROADWAY NEW YORK IN ANSWER TO HIS TELEGRAM TODAY THAT OUR SHORT WAVE STATIONS HAVE BEEN ON THE AIR SO SHORT A TIME THAT IT ISIMPOSSIBLE TO GIVE MUCH INFORMATION ON RETURNS STOP WE RE USING 30 AND 100 METER STATION AND HAVE NIGHT TRANSMISSON ONLY STOP GREATEST DISTANCE THUS FAR ON EITHER WAVE IS LONDON ENGLAND WHERE WE ARE RECEIVED NIGHTLY STOP IRVIN H. REEVES OF LONDON REPORTS NIGHTLY RECEPTION STATING THAT WE COME THROUGH EARLY MORNING DAYLIGHT WITHOUT ANY AFFECT ON SIGNAL.

W T MEEHAN 4:56

WOC—CYL Mexico City 510—2FC Sydney 1100—KFI—PA5 Amsterdam 1050—Vienna—Colombo—WWJ—WCX Lakehurst 80—ICE Rome 470—5PY Plymouth 330—Voxhaus 430—CNRC Calgary 440—Madras—Stuttgart 437 BAV Brussels 1100—6FL Sheffield 303—WGY 38—PCGG Hague 1050—Otchiski—KGW—CFAC 430—CHXC Ottawa—EBX Cartagena—NAA 2500—PCMM Ymuiden 1050—SBR Brussels 262—KHJ—LOX Palermo 375—OXE Lyngby 2400—KOA—2SB Sydney—OKP Kbely 1150—2BE Belfast 435—KGO—YN Lyons 470—I Nice 360—FL Eiffel Tower 2600—PTT Paris 450—5XX Chelmsford 1600—LOZ Monte Grande 425—2LS Leeds 346—5MA Adelaide 850—2LO London 365—PWX Havana 400—RAS Vladivostok—WMBF—CJCM Mont Joli—LOR Buenos Aires 400—LP Berlin 2370—VTR Rangoon

3LO Melbourne 1720
6BM Bournemouth 385
5WA Cardiff 350
PRG Prague 1800
2ZY Manchester 375
HB2 Lausanne 850
JJC Funabashi
JSB Chemulpo
3FL Melbourne 400

6VL Liverpool 318
HBI Geneva 1100
KDKA 64
POZ Berlin 2800
2EH Edinburgh 325
51T Birmingham 475
Munich 485
Leipzig 452
2BD Aberdeen 495

THE NEW UNIVERSAL PLIO-6

Six tube, 2 Stages Non-Regenerative Tuned Radio Frequency Amplification, Detector and 3 Stages Distortionless Radio Amplification. Receiving range from 1,000 to 12,000 miles depending upon location, station transmitting, wave-length received and other variable factors

FULL DETAILS NOW AVAILABLE FROM MANUFACTURERS

GOLDEN-LEUTZ INC.

476 BROADWAY :-: NEW YORK CITY

Manufactured under Hogan Patent 1,014,002 - Other Patents Pending **CABLES "EXPERINFO" NEW YORK**

Approved, Endorsed, Recommended!

THE CARBORUNDUM DETECTOR

Eminent radio engineers, radio authorities and writers have given unstinted praise to the Carborundum Detector for reflex and crystal sets.

The Carborundum Detector has earned their compliments because:

It is the one detector made with a Carborundum specially developed for radio purposes.

This detector is fixed permanent—No cat's whisker nuisance.

It sharpens the tuning, increases volume and selectivity, brings in true, clear tones.

It is highly sensitive yet rugged. It won't burn out.

The Carborundum Detector is guaranteed.

THE CARBORUNDUM COMPANY
NIAGARA FALLS, N. Y.

$1.50
IN U. S. A.
From Dealers or Direct

Radio Dealers WANTED!

If you are the type of dealer who hustles after business, who isn't content to wait for trade to come in but who takes sets out to demonstrate, can talk and sell quality merchandise, and knows Radio values, we have a big proposition for you. Are you that dealer?

50% DISCOUNT TO DEALERS

We manufacture a complete line of high grade receivers and sell to dealers at 50% discount. We are authorized distributors for more than 225 Nationally advertised lines.

Write today for amazing offers, new 112-page catalog and regular monthly catalogs quoting below-the-market prices on latest merchandise—all free. Everything in Radio for less. Just fill in coupon, pin to your letter head and mail today, NOW.

AMERICAN RADIO MFG. CO.
1416-18 McGee Street, Dept. P., Kansas City, Mo.

AMERICAN RADIO MFG. CO., 1416-18 McGee St.,
Dept. P, Kansas City, Mo.

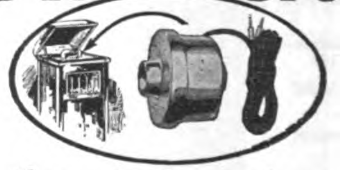
Gentlemen: Mail me your new 112-page catalog. Also put me on list for regular monthly mailings.

Name..

Address..

City..............................State..........

Morrison



Loud Speaker

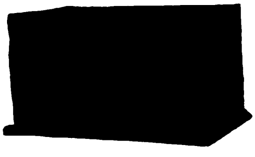
MATCHLESS REPRODUCTION

With the Mocking Bird Unit and Your Phonograph

Price $5.00

For complete enjoyment of all that is best in radio, for purity of tone and plenty of volume on distant stations, be sure your set reproduces through a Morrison Unit—a standard for four years. Attach the Mocking Bird Unit to the tone arm of your phonograph (fits all popular makes) and you have the finest possible means of reproducing radio reception.

Mocking Bird Cabinet $30,

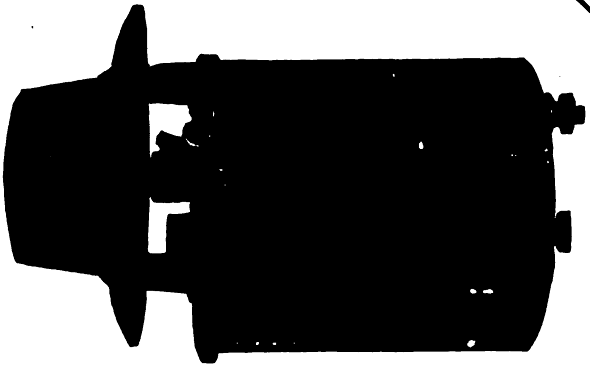


Dealers
Be sure your holiday orders are in early. Remember the rush for Morrison Loud Speakers will surpass all previous years.

Set Mfrs.
We are able to supply unit in quantity orders at attractive prices. Deliveries are assured with acceptance of order.

The Mocking Bird Cabinet is the peer of all loud speakers. You will be proud of your Mocking Bird—not only its performance but the artistry of its design and workmanship.
If you dealer cannot supply you send money order or check to factory. If you prefer we will ship C.O.D. Every Unit sold on money back guarantee.

MORRISON LABORATORIES
345 E. Jefferson Avenue, Detroit, Mich.



PATENTS PENDING

"The Most Practical SLF Condenser I've Seen"

So commented a prominent radio engineer recently, after testing the new Furnell Taper Coil Condenser.

The Furnell stands absolutely alone. It is the first radical improvement in condensers—and the only one of its type on the market.

Literally thousands—including "fans," manufacturers, engineers, distributors, jobbers, dealers, etc.—have been showing a phenomenal interest in this remarkable new condenser.

Professionals recognize in the Furnell the most practical type of condenser ever designed for Straightline Frequency tuning. It affords a wonderful smoothness of operation and a scientific precision absolutely impossible with the old style condenser.

The Furnell Condenser assures a clean-cut separation of all stations, regardless of wavelength, and affords the clearest and smoothest reception you have ever enjoyed.

And the strong, transparent Pyralin shield keeps the Furnell absolutely dust-proof, moisture-proof, and damage-proof, thereby insuring permanent accuracy and precision. Made in three capacities—single and multiple.

Write for literature

Furnell Condensers will not be ready for sales distribution until December. We invite your interest in awaiting this new and radical condenser achievement.

The FURNELL MANUFACTURING CORPORATION

24F SCOTT ST., NEWARK, N. J.

FURNELL

360° TAPER COIL CONDENSERS

Unusual Features

Increase Receiving Efficiency

The Ultra-Lowloss Condenser has proved its right to leadership by greatly simplifid design, greater tuning efficiency, and radically different operating results—not only in the eyes of scientific and engineering men, but with the buying public as well.

These are the pre-dominating Ultra Lowloss features: (1) Single insulation strip reduces leakage losses materially. (2) Monoblock mounting with plates cast into block reduces series resistance and assures positive contact. (3) Minimum of metal of high resistance material in the field and frame reduces eddy current losses. (4) Cutlass Stator Plates produce a straight line wavelength curve—separating stations evenly over dial. Each degree on a 100 degree scale dial represents approximately 3½ meters over the broadcast wavelength range. This even separation applies to both high and low wavelengths. Simplifies tuning materially!

At your dealers. Otherwise, send purchase price and you will be supplied postpaid.

R E L

This seal (R. E. L.) is your assurance of Lacault design.

ULTRA-LOWLOSS
CONDENSER
PHENIX RADIO CORPORATION
116 East 25th St. New York, N. Y.

HOLIDAY GIFT OFFER

SEND

POPULAR RADIO

for one year
and
Handsome Christmas Card
for

$2.50

(Gift subscriptions only)

NO finer gift to relations or friends, who are interested in radio, can be made, this year, than a year's subscription for POPULAR RADIO, with which is combined "The Wireless Age." Each month for twelve months POPULAR RADIO will carry the reminder of your kindly thought, will keep green the holly of your friendship, and will give to the recipient, of any age, more genuine pleasure and practical help than any other gift you might send.

The universal interest in radio, the low price, and the Christmas Card, which we will send, make it possible for you to avoid the worry of "What shall I give—" and by sending in your order now you can be assured that on Christmas morning, and for twelve months thereafter, your friends will receive a tangible evidence of your Christmas Greeting and your desire for their future pleasure.

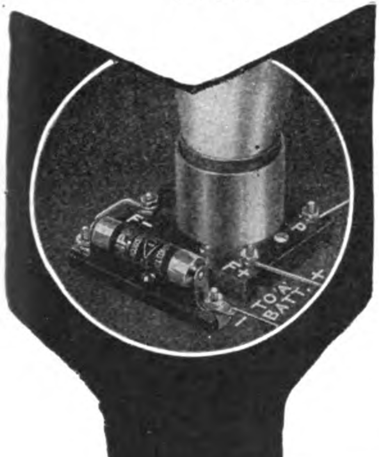
Send in your list early, and avoid possible delay in receipt of the Christmas Card announcing your gift.

POPULAR RADIO
Department 127A
627 West 43d St. NEW YORK CITY

AMPERITE

REG. U.S. PAT. OFF

The "SELF-ADJUSTING" *Rheostat*



A BASIC Need in Every Circuit

BECAUSE—AMPERITE not only modernizes any set—it keeps it modern.

1—Eliminates Hand Rheostats, thereby simplifying control.

2—Permits use of the latest types of tubes or any combination of tubes.

3—Simplifies and reduces set-wiring, thereby making for greater compactness and avoids losses.

4—No moving parts, hence no grinding noises; clear and full tones.

5—Prolongs tube-life by keeping filaments at a constant temperature.

6—No filament meters needed.

7—Brings the most out of each individual tube — automatically—no guessing.

8—Makes every set-owner a master operator, no knobs to turn.

Write today for FREE Hook-Ups

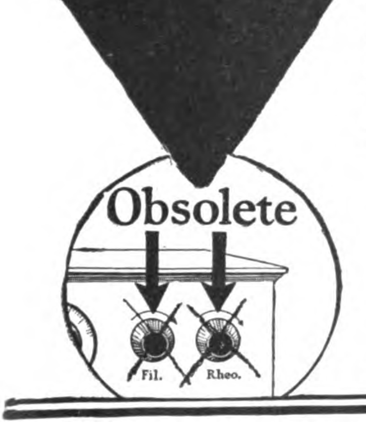
Sold Everywhere

$1.10 complete with mounting (in U. S. A.)

AMPERITE is used in every popular present-day construction set. Why? Because of its many outstanding exclusive features, and because it solves the perplexing problem of tube-control—COMPLETELY and AUTOMATICALLY.

For the new tubes:

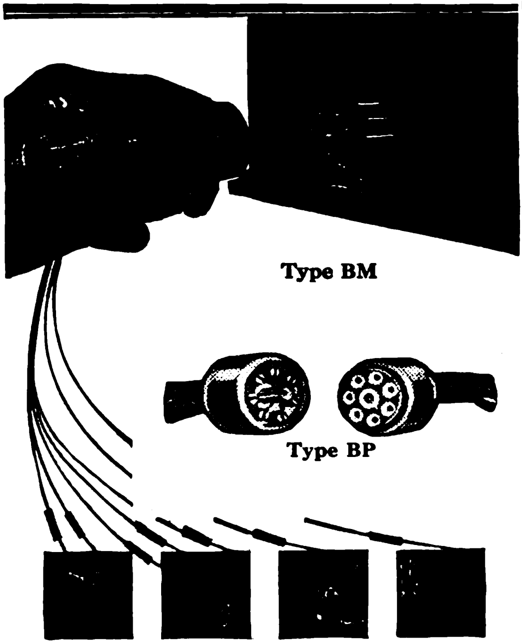
Amperite No. 112—for the UX-112 and CX-112
Amperite No. 120—for the UX-120 and CX-120



Radiall Company

Dept. P.R.-15 50 Franklin Street New York City
Mf's of "TUNE-RITE" Straight-Line-Frequency Dial

Be sure that the set you buy or build is equipped with AMPERITE.



Jones
MULTI-PLUG
THE STANDARD SET CONNECTOR

YOU wouldn't have an auto without a self starter. THEN why a radio set without a Multi-Plug?

BUY BUILD EQUIP
YOUR RADIO
with a MULTI-PLUG

Affording a plug and socket connection between the radio set and all outside connections, Jones Multi-Plug is as essential to the radio as a cord and socket to the electric iron.

Type BM—For Set Building—$4.50.
Type BP—Adaptable to any set—$5.00.

HOWARD B. JONES, CHICAGO, ILL.
618 S. Canal Street

The New Transformer

MODERN-SYMPHONY

Covers the Entire Range of Musical Frequencies

The new Modern-Symphony Transformer has been especially designed to reproduce and amplify the range of sound frequencies of any great orchestra. It will bring to you with equal faithfulness the basso profundo or the high treble. The new Modern-Symphony Transformer will delight you. Besides, it is built by a manufacturer of Standard Equipment.

MODERN ELECTRIC MANUFACTURING CO., Toledo, Ohio

The real solution to the tuning problem!

MAKE your radio a 1926 model. Replace your present Dials with *Rathbun Straight Line Frequency Converters* which spread all stations within the range of your receiver uniformly around the whole circle of 360°. All stations are a uniform distance apart on these new Converters which is the ideal tuning condition.

Why be satisfied with Dials or Condensers which are limited to 180° or only half the dial? Why stop at 180° when there are 360° in the circle? No gears with their back lash, no friction with its slippage in *Rathbun Straight Line Frequency Converters*—only two moving parts, a variable cam and a lever. Easily and quickly installed on any set—it is not necessary to cut Condenser shafts or drill panels.

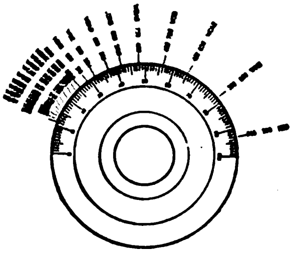
The *Rathbun Straight Line Frequency Converter* is one of the few really new things in Radio during the past three years.

Don't forget that we build the *Rathbun Single Hole Mounting Condenser* with genuine Bakelite ends. This year's models are all enclosed with transparent pyralin dust bands which preserve their high efficiency for life. Small, light, rugged, handsome and none lower loss or higher in efficiency. *Reasonably priced.*

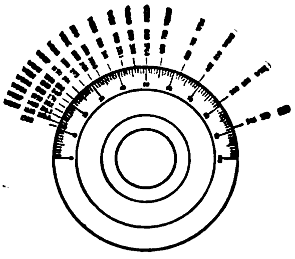
Ask your dealer for Rathbun Straight Line Frequency Converters. If he has not yet stocked them, he will quickly obtain them

PRICE $3.50

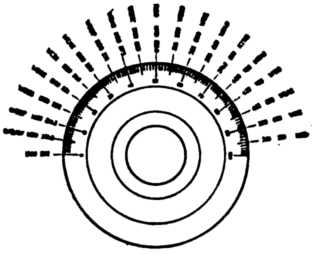
Rathbun Manufacturing Co., Inc.
Jamestown, N. Y.



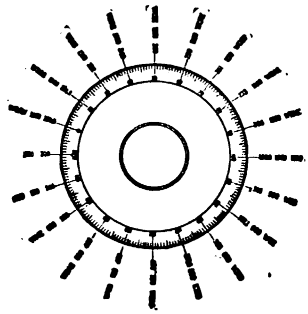
Stations indicated in kilocycles and wave lengths showing crowding with an ordinary capacity condenser



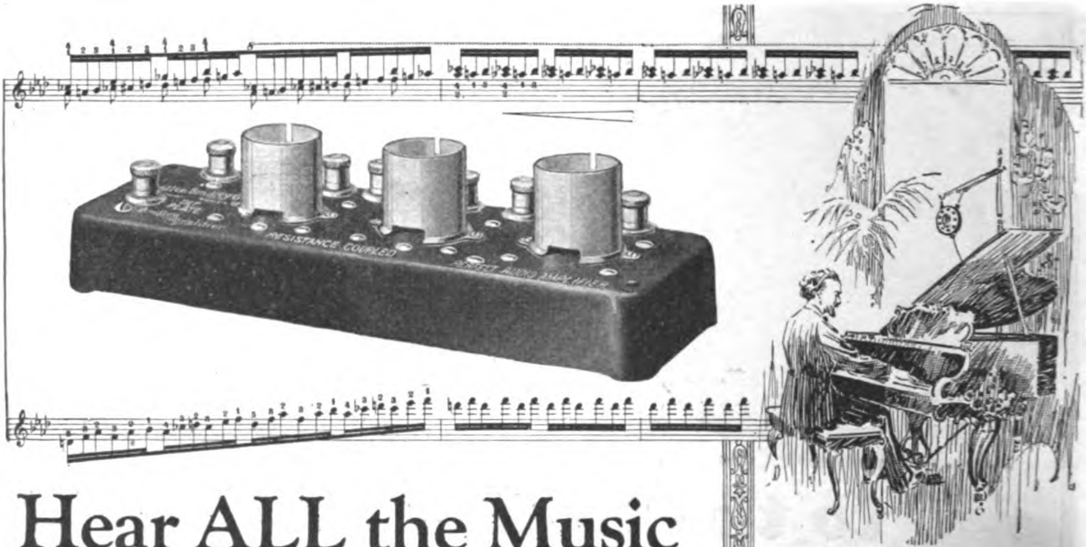
Stations partially separated and tuning slightly improved with a Straight Line Wave Length Condenser



Practically even separation over half the dial with a Straight Line Frequency Condenser



Complete and equal separation of stations over the entire dial with the Rathbun Straight Line Frequency Converter



Hear ALL the Music

with the Bradley-Amplifier

THE delicate variations and shadings of instrumental music and the exquisite strains of the vocalist are amplified with faithfulness and clarity by the Bradley-Amplifier. It matters not whether you own a factory-built set or a home-built receiver, either will be improved by using the Bradley-Amplifier.

Bradleyunit resistors, that are impervious to moisture and unaffected by atmospheric changes, take the place of the audio-frequency transformers of ordinary amplifiers. There is no distortion and no loss of low or high frequencies. All tones are reproduced with equal facility.

Ask your dealer for the Bradley-Amplifier today and substitute it for your present audio-frequency amplifying transformers. Resistance coupled amplifiers are acknowledged by radio experts to be the most perfect type of amplifier. You can make your set perfect with a Bradley-Amplifier.

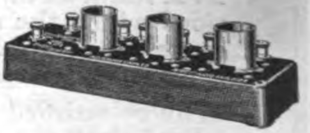
Retail Prices—In U. S. A. $15

—In Canada $21

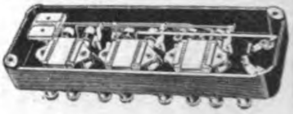
Allen-Bradley Co.
Electric Controlling Apparatus

A-B

MILWAUKEE,
WISCONSIN



Can be installed within radio cabinet. UX as well as old tubes can be used.



All resistors, condensers, and wiring, are concealed within Bakelite base.

Bradleyunit resistor is made of solid molded material which does not change with age. All units are soldered.

ALLEN-BRADLEY CO.
276 Greenfield Ave., Milwaukee, Wisconsin
Please send me your latest literature on the Bradley-Amplifier, explaining how it will improve my receiver.
Name..............................
Address..............................
....

Mail the Coupon

The wonderful performance of these CROSLEY Radios will be duplicated this year—and with these New Prices they should be Radio's best values!

Crosley 2-Tube 51 Regular

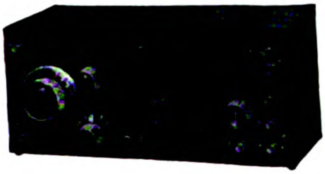
This efficient little set uses any make of tubes. Nearby stations on loud speaker, long range on headphones.

Now $\$14^{75}$, was $\$18^{50}$

Crosley 3-Tube 52 Regular

For a less expensive 3-tube set the Crosley 52 Regular cannot be surpassed at the new low price.

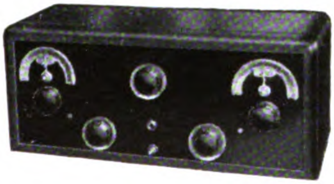
Now $\$25$ was $\$30$



Crosley Super-Trirdyn Regular

In the Super-Trirdyn, 3 tubes do the work of 5. Matchless performance. Beautifully finished solid mahogany cabinet.

Now $\$45$ was $\$50$



Low Power Stations Heard Across the Country with the Crosley 3-Tube 52

"One big asset of Crosley '52' is its ability to pick up low powered broadcast. I have picked up KFON, Long Beach, California, and KFUM, Colorado Springs, Colorado, both stations using only 100 watts and EFEL a 50 watt station in Denver."

PHILLIP S. WILLIAMS, Bristol, Pa.

Lives in California—Lists 35 Stations East of Rockies Heard on Loud Speaker

J. F. McGinley living in Hallster, California, sends us a list of stations in the East including Ohio, Pennsylvania and New York, whose broadcasting he enjoys constantly on his loud speaker. He emphasizes the fact that he owns *no* ear phones.

"Coast to Coast" Reception With a Crosley 3-Tube 52

"I have a record of reception of practically all the large radio stations in this country and Canada from WBZ, New England to WMBF, Miami; from Fort Worth, Texas, to CURT, Toronto; and from CYL, Mexico City to KGW, Portland, Oregon and KFI, Los Angeles."

WALTER HAGERTY, Burlington, Iowa

Spruce, Michigan, Is Within Earshot of Europe with a Crosley 3-Tube 52

"During the International test last year I heard the following stations clearly and distinctly: 'Paris, Berlin, London, Honolulu, and Porto Rico.' 6 and 8 tube sets in my neighborhood don't begin to compare with my "Little Wonder.'"

ELLIS C. MARTIN, Spruce, Michigan

Vancouver to Torrington, Connecticut, Is a Short Distance for the Crosley 2-Tube 51

"Following are only a few of the stations I have received: WBAP, Fort Worth, Texas; 6 KW, Cuba; KOA, Denver, Colorado; WTG, Manhattan, Kansas; KPO, San Francisco; Manchester, England and Vancouver, for which I can furnish sworn statements if desired."

HARRIS C. RODSEFELLOW, Torrington, Conn.

The Famous MUSICONE

This marvelous loud speaker—well on its way to REPLACE HALF A MILLION HORN TYPE SPEAKERS by January 1st—is substantially reduced because of assembly improvements developed by Crosley engineers. Reproduces all tones—without distortion. Crosley patented unit, not cone, secret of its amazing perfection.

Now $\$14^{75}$ was $\$17^{50}$

CROSLEY · RADIO

BETTER · COSTS LESS

THE CROSLEY RADIO CORPORATION Department 16, Cincinnati

These prices do not include accessories. Add 10% to all prices West of the Rockies

PRESS OF WILLIAM GREEN, NEW YORK

RCA

No matter what set you buy, be sure the dealer puts in *genuine* Radiotrons:

UV-199	$2.50
UX-199	$2.50
UX-120	$2.50
UV-201-A	$2.50
UX-201-A	$2.50
UV-200	$2.50
UX-200	$2.50
WD-11	$2.50
WD-12	$2.50
WX-12	$2.50
UX-112	$6.50
UX-210	$9.00
Rectrons:	
UX-213	$7.00
UX-216-B	$7.50

A "UX" or "WX" tube is the same as the corresponding "UV" or "WD" tube, except in the design of the base.

for every
Christmas Radio Set
use only genuine RCA Radiotrons

READ all the claims of all the makers of radio sets—and then remember this when you buy—that getting what is claimed for a set depends upon the quality of the *vacuum tube* put into it. You cannot get clearness—you cannot get distance—you cannot get volume—unless the *tubes* get it. That is why it is so important to look at the base of every tube, to be sure it is a *genuine* RCA Radiotron.

A great gift for any fan—at $2.50

A radio fan will appreciate a "spare" Radiotron, just as an autoist appreciates a spare tire. But the Radiotron—a genuine RCA Radiotron—costs only $2.50. If you note what make of set a man owns, any dealer can tell you which *type* of Radiotron he uses, and you can give him exactly what he would choose for himself.

for owners of Super-Heterodynes — the new power tube

Every owner of a Radiola Super-Heterodyne can bring his set right up-to-date with the latest improvement, if you give him the new dry battery power Radiotron UX-120, and the adapter. The adapter costs but $1.50. And this new tube means great volume with better tone than ever!

Radiotron UV-201-A, standard high-vacuum tube for storage battery sets

RADIO CORPORATION OF AMERICA
CHICAGO NEW YORK SAN FRANCISCO

RCA-Radiotron

MADE BY THE MAKERS OF RADIOLAS

BOUND
AUG 30 1926
UNIV. OF MICH.
LIBRARY

UNIVERSITY OF MICHIGAN
3 9015 07494 3351